OPERATING AND SERVICE MANUAL

MODULAR POWER SUPPLIES

MODELS 61005E, 61315E, 63005E, AND 63315E

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CERTIFICATION

Hewlett-Packard Company certifies that this product met its published specifications at the time of shipment from the factory. Hewlett-Packard further certifies that its calibration measurements are traceable to the United States National Bureau of Standards, to the extent allowed by the Bureau's calibration facility, and to the calibration facilities of other International Standards Organization members.

WARRANTY

This Hewlett-Packard instrument product is warranted against defects in material and workmanship for a period of one year from date of shipment. During the warranty period, Hewlett-Packard Company will, at its option, either repair or replace products which prove to be defective.

For warranty service or repair, this product must be returned to a service facility designated by HP. Buyer shall prepay shipping charges to HP and HP shall pay shipping charges to return the product to Buyer. However, Buyer shall pay all shipping charges, duties, and taxes for products returned to HP from another country.

HP warrants that its software and firmware designated by HP for use with an instrument will execute its programming instructions when properly installed on that instrument. HP does not warrant that the operation of the instrument, or software, or firmware will be uninterrupted or error free.

LIMITATION OF WARRANTY

The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by Buyer, Buyer-supplied software or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

NO OTHER WARRANTY IS EXPRESSED OR IMPLIED. HP SPECIFICALLY DISCLAIMS THE IMPLIED WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE.

EXCLUSIVE REMEDIES

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ASSISTANCE

Product maintenance agreements and other customer assistance agreements are available for Hewlett-Packard products.

For any assistance, contact your nearest Hewlett-Packard Sales and Service Office. Addresses are provided at the back of this manual.

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MODULAR POWER SUPPLIES

MODELS 61005E, 61315E, 63005E, AND 63315E

OPERATING AND SERVICE MANUAL FOR:
MODEL 61005E, SERIALS 2207A—00101 AND ABOVE *
MODEL 61315E, SERIALS 2203A—00101 AND ABOVE *
MODEL 63005E, SERIALS 2203A—00101 AND ABOVE *
MODEL 63315E, SERIALS 2209A—00101 AND ABOVE *

*For instruments with serial numbers above those listed, a change page may be included.

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SECTION I
GENERAL INFORMATION

1-1 DESCRIPTION

1-2 This manual covers two dc-input and two ac-input 110-watt switching-regulated power supplies. Each input type includes a single-output and a triple-output model. The Model 61005E uses a 42-volt to 56-volt (48-volt nominal) dc input to produce a single 4.75 to 5.25 volt (5-volt nominal) 22-amp dc output. The Model 61315E uses a 48-volt nominal dc input to produce three dc outputs, a 5-volt output with a load capacity of up to 18 amps and a pair of dual-tracking outputs adjustable from under ±12 volts to over ±15 volts with load capacities of up to 2 amps each. The negative dual output tracks the positive one within ±1% +20 mV. The outputs of the Model 61315E can be operated anywhere within their 18-amp, 2-amp, and 2-amp individual current limitations provided that the total output power does not exceed the supply's 110-watt total output rating. (Figure 3-5 is a graph of the load sharing restrictions of the triple-output models.)

1-3 The two ac-input models have the same dc output ratings as the dc-input models. The single-output Model 63005E and the triple-output Model 63315E are designed to operate from a single-phase 48 to 63Hz source with a voltage range of either 87 to 127Vac or 180 to 250Vac. One of these input voltage ranges is selected by positioning jumpers on an external barrier strip.

1-4 The dc-input models are protected against an input overvoltage or an input polarity reversal. The ac-input models are SCR preregulated. All models use an advanced design 20kHz transistor switching regulator for their 5-volt outputs. The ±12 to ±15-volt outputs of the triple-output models are (V2 and V3) preregulated by the switching regulator for the 5-volt output and then regulated by linear transistor series regulators.

1-5 In all models, adjustable foldback current limit circuits protect all outputs against overload or short circuit damage. Fixed overvoltage protection crowbar circuits are activated at 6.2 ±0.3V at the 5-volt output (V1) and 16.1 to 17.9 volts at the ±12 to ±15-volt outputs (V2 and V3). The crowbar circuits reduce all outputs to less than 2 volts if any one output exceeds its trip voltage.

1-6 The 5-volt and the ±12 to ±15-volt outputs are isolated from the chassis and from each other and may be grounded at the ground terminal provided or floated at up to 42 volts above ground.

1-7 SPECIFICATIONS

1-8 Table 1-1 lists detailed specifications for these power supplies.

1-9 INSTRUMENT AND MANUAL IDENTIFICATION

1-10 Hewlett-Packard power supplies are identified by a two-part serial number. The first part is the serial number prefix, a number-letter combination that denotes the date of a significant design change and the country of manufacture. The first two digits of the prefix indicate the year (20 = 80, 21 = 81, etc.), the second two digits indicate the week, and the letter "A" designates the USA as the country of manufacture. The second part of the serial number is a different sequential number assigned to each power supply, starting with 00101.

1-11 If the serial number on your instrument does not agree with those on the title page of this manual, a yellow change sheet supplied with the manual defines the difference between your instrument and the instrument described by this manual.

1-12 ORDERING ADDITIONAL MANUALS

1-13 One manual is shipped with each power supply. Additional manuals may be purchased from your local Hewlett-Packard field office (see list at rear of this manual for addresses). Specify the model number, serial number prefix, and HP Part number provided on the title page.

1-14 Extra manuals may be obtained by ordering Option 9120 when ordering your instrument. The number of extra manuals depends on the number of Option 910's ordered.

Table 1-1. Specifications, Models 61005E and 61315E (dc input), and Models 63005E and 63315E (ac input).

INPUT VOLTAGE:

DC Input Models — 61005E and 61315E 48Vdc nominal; range 42V to 56Vdc.

AC Input Models — 63005E and 63315E 87 to 127Vac or 180 to 250Vac, single-phase, 48-63Hz: Voltage range changeable on external terminal block.

INPUT CURRENT AND POWER:

DC Input Models

Model Number	Input Power	Max. Input Current (42V Input)
61005E	210W	5A
61315E	230W	5.5A

AC Input Models

Model Number	Input Power	Max. Line Current (127V/250V)
63005E	195W	3.6A/3.2A
63315E	220W	3.9A/3.6A

INPUT PROTECTION:

DC Input Models — A 6A fuse in series with the negative input lead is accessible at the terminal end of the supply. The supply is undamaged by any input between zero and 56 volts; Input Voltage surges above approximately 65Vdc will cause the supply to latch off until the input voltage has dropped to a safe level. The supply is protected against a reverse input polarity by a shunt diode that blows the fuse.

AC Input Models — Input protected by an internal 5A fuse.

INPUT SURGE CURRENT:

DC Input Models — Less than 80A peak at turn on.

AC Input Models — Less than 15A peak ac inrush at turn on.

OUTPUT RATINGS: (Screwdriver voltage adjustments are accessible through holes in the panel.)

Single-Output Models (61005E and 63005E)

V1 4.75 to 5.25Vdc 22A

Triple-Output Models (61315E and 63315E)

V1 4.75 to 5.25Vdc 18A*

V2 +11.440 to +15.75Vdc 2A*

V3 −11.40 to −15.75Vdc 2A*

(*Maximum load currents cannot be obtained simultaneously. 110 watts is the maximum available output power. See Figure 3-5 for load sharing tradeoff.)

DUAL OUTPUT TRACKING ACCURACY:

Triple-Output Models — V2 and V3 outputs track within ±1% of 20mV.

CARRYOVER TIME:

AC Input Models — Output voltage remains within 2% of specified nominal for more than 8.0msec while delivering full load current following removal of ac input power at 87Vac, or at 180Vac.

SOURCE EFFECT:

DC Input Models — Less than 0.1% for any change within the specified input voltage rating.

AC Input Models — Less than 0.01% +1mV for any change within the specified input voltage rating.

LOAD EFFECT:

All Outputs — Less than 0.04% +3mV for a load current change equal to the current rating of the output.

PARD (Ripple and Noise):

All Outputs: Less than 5mV rms and 40mV p-p (20Hz to 20MHz).

LOAD TRANSIENT RECOVERY TIME:

5 Volt (V1) Output — Less than 600μs for output recovery to within 1% of nominal output voltage following an 80% to 100% load transient.

±12 to ±15V (V2 and V3) Outputs — Less than 25μs for output recovery to within 1% of nominal output voltage following a load change from full to half load or vice versa.

DRIFT:

Change in output (dc to 20Hz) is less than 0.1% over an 8-hour interval following a 30-minute warmup.

TEMPERATURE COEFFICIENT:

All Outputs — Less than 0.015% output voltage change per degree Celsius over the operating range from 0 to 40°C at constant load and line voltage after 30 minutes warmup.

TEMPERATURE RANGES:

Operating Temperatures — 0 to 40°C ambient at full rated output. Above 40°C, derate output current linearly to 50% of maximum at 70°C.

Storage Temperatures — −55°C to +85°C.

Table 1-1. (Continued)

COOLING:

Convection cooled. (In some applications, can be conduction cooled through surface at end of case after removing finned heatsink. Consult factory for recommendations.) At least ½ inch. Clearance is required at the bottom of the unit to permit proper air flow.

OVERTEMPERATURE PROTECTION:

Heatsink-mounted thermostat shuts off output(s) if supply overheats due to high ambient temperature. Thermostat automatically resets when unit cools to safe operating temperature.

OUTPUT OVERCURRENT PROTECTION:

Accessible screwdriver adjustment(s) are factory set to limit load current to approximately 110% (5V output) or 130% (±12 to ±15V outputs) of rated maximum current. Foldback current limit characteristics are shown in Figures 3-6 and 3-7. Adjustment range is approximately 55% to 120% of rated load current in single-output models and 65% to 140% in triple-output models.

OUTPUT OVERVOLTAGE PROTECTION:

A non-adjustable overvoltage crowbar reduces output(s) to less than 2 volts when trip level of 6.2 ±.3V is exceeded at the 5V output or when 16.1 to 17.9 volts is exceeded at either 12 to 15V output. In the triple-output models, an overvoltage trip at any one output shuts down all three outputs.

OUTPUT REVERSE VOLTAGE PROTECTION:

All Models — Shunt diodes protect all outputs from damage due to the application of a reverse polarity voltage at currents up to the current rating of the respective power supply output.

REMOTE SHUTDOWN:

A contact closure or TTL (low) input between the 5V output's (−) or (−SEN) terminal and terminal E6 reduces the supply's output voltages to a low value. The 5 volt V1 output will drop to less than 1.6 volts @ no load, and less than .90 volts with a lamp load. The outputs return to normal on opening the contact or switching to a high logic level.

REMOTE SENSING:

Remote sensing terminals are provided that will correct for a load lead voltage drop of up to 5% while maintaining nominal voltage at the load. The load is protected if the sensing leads are inadvertently opened.

DIELECTRIC WITHSTAND VOLTAGE:

DC Input Models —
Input to any output, 1000Vdc for 1 minute.
Input to case, 1000Vdc for 1 minute.
Any output to case, 500Vdc for 1 minute.

AC Input Models —
Primary to any output, 1500V rms for 1 minute.
Primary to case, 1500V rms for 1 minute.
Any output to case, 500Vdc for 1 minute.

INSULATION RESISTANCE:

DC Input Models —
Input to any output, 100 meghoms minimum (500Vdc).
Input to case, 100 megohms minimum.
Any output to case, 10 megohms minimum.

AC Input Models — Between 5V output and ±15V output, 10 megohms minimum.
Any output to case, 10 megohms minimum.

SAFETY STANDARDS:

Designed to conform to recommendations of IEC 348. Approved by UL for inclusion in their Recognized Component Index under Guide QQFU2, File E51529.

EMI CHARACTERISTICS:

DC Input Models — Comply with VDE 0871/6.78 Category A.

AC Input Models — Comply with VDE 0871/6.78 Category A.

DIMENSIONS:

(See outline diagrams in Section II).

WEIGHT (Net/Shipping):

Model 61005E 2.1kg (4.7 lb)/3.0kg (6.7 lb)
Model 61315E 3.0kg (6.7 lb)/3.9kg (8.7 lb)
Model 63005E 3.6kg (8.0 lb)/4.5kg (10 lb)
Model 63315E 4.6kg (10 lb)/5.5kg (12 lb)

SECTION II
INSTALLATION

2-1 INITIAL INSPECTION

2-2 Before shipment, this instrument was inspected and found to be free of mechanical and electrical defects. As soon as the instrument is unpacked, inspect for any damage that may have occurred in transit. Save all packing materials until the inspection is completed. If damage is found, a claim should be filed with the carrier immediately. Also, a Hewlett-Packard Sales and Service office should be notified.

2-3 Mechanical Check

2-4 This check should confirm that there are no broken connectors and that the panel surfaces are free of dents and scratches.

2-5 Electrical Check

2-6 The instrument should be checked against its electrical specifications. Section V includes an "in-cabinet" performance check to verify proper instrument operation.

2-7 INSTALLATION DATA

2-8 The instrument is shipped ready for permanent installation or bench operation. It is necessary only to connect the instrument to a source of power and it is ready for operation.

2-9 Location and Cooling

2-10 This instrument is aircooled. Sufficient space should be allotted so that a free flow of cooling air can reach the instrument when it is in operation. At least ½ inch clearance at the bottom of the unit is required to permit proper air flow. The supply should be used in an area where the ambient temperature does not exceed 40°C. If operated at an ambient greater than 40°C, the supply's output current must be linearly derated down to 50% at 70°C.

NOTE

This instrument is air cooled, at least ½ inch clearance is required at the base to permit proper air flow.

2-11 It is also possible to cool this supply through conduction by removing its finned heatsink and mounting the rear surface of the supply to a suitable heat-conducting surface. Consult the factory for specific recommendations.

2-12 Mounting Orientation

2-13 Figures 2-1 through 2-4 provide outline and dimension information. As shown in these figures, four mounting holes are provided on the bottom of the supply and four more are available at the rear if the heat sink is removed. If these supplies are cooled by natural convection, the upright position is the only orientation recommended. If they are cooled by forced air they may be mounted in any position.

2-14 Input Power Requirements

2-15 Models 61005E and 61315E. The Models 61005E and 61315E are designed for a nominal input of 48 volts dc. They can operate over an input range of 42 to 56 volts dc. Their maximum input currents are 5 amps and 5.5 amps, respectively, and they draw a maximum input power of 210 watts and 230 watts.

2-16 Models 63005E and 63315E. The Models 63005E and 63315E may be operated from an 87 to 127Vac or a 180 to 250Vac, single-phase, 48 to 63Hz power source and can be adapted for either of these input voltage ranges by the positioning of jumpers on terminals E1 through E5 on TB1. For 87 to 127V operation, jumper E1 to E2 and E4 to E5. For 180 to 250V operation, jumper E3 to E4 only. (When it is shipped, the supply's input jumpers are connected for 187 to 127Vac operation.) See Table 1-1 for input current requirements. The maximum input power is 195 watts for the Model 63005E and 220 watts for the Model 63315E.

2-17 REPACKAGING FOR SHIPMENT

2-18 To insure safe shipment of the instrument, it is recommended that the package designed for the instrument be used. The original packaging material is reusable. If it is not available, contact your local Hewlett-Packard field office to obtain the materials. This office will also furnish the address of the nearest service office to which the instrument can be shipped and provide the Authorized Return label necessary to expedite the handling of your instrument return. Be sure to attach a tag to the instrument which specifies the owner, model number, full serial number, and service required, or a brief description of the trouble.

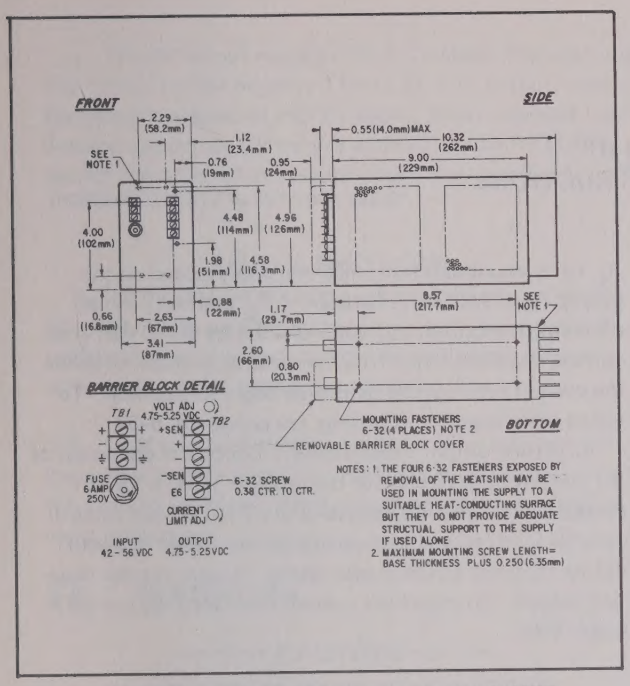
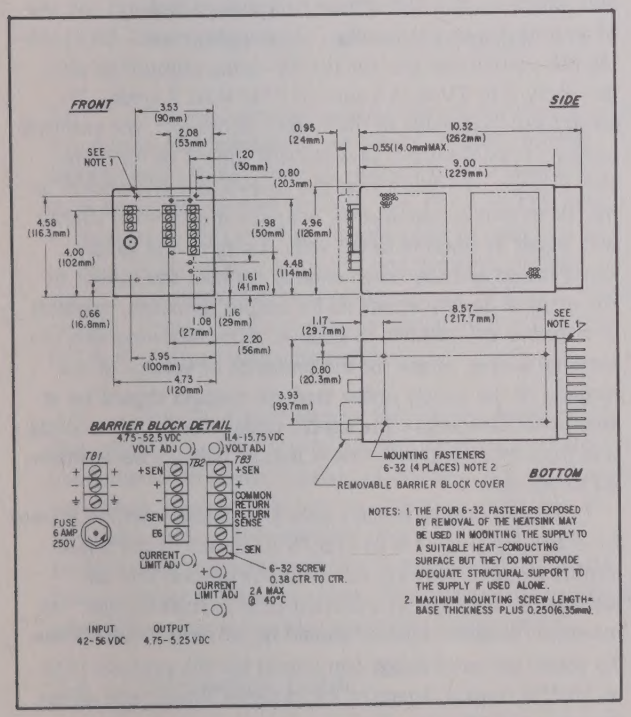

FRONT
SIDE
BARRIER BLOCK DETAIL
BOTTOM
MOUNTING FASTENERS
6-32 (4 PLACES) NOTE 2
REMOVABLE BARRIER BLOCK COVER
NOTES: 1. THE FOUR 6-32 FASTENERS EXPOSED BY REMOVAL OF THE HEATSINK MAY BE USED IN MOUNTING THE SUPPLY TO A SUITABLE HEAT-CONDUCTING SURFACE BUT THEY DO NOT PROVIDE ADEQUATE STRUCTUAL SUPPORT TO THE SUPPLY IF USED ALONE
2. MAXIMUM MOUNTING SCREW LENGTH= BASE THICKNESS PLUS 0.250 (6.35mm)

Figure 2.1. Outline Diagram, Model 61005E


FRONT
SIDE
BARRIER BLOCK DETAIL
BOTTOM
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2. MAXIMUM MOUNTING SCREW LENGTH= BASE THICKNESS PLUS 0.250(6.35mm).

Figure 2-2. Outline Diagram, Model 61315E

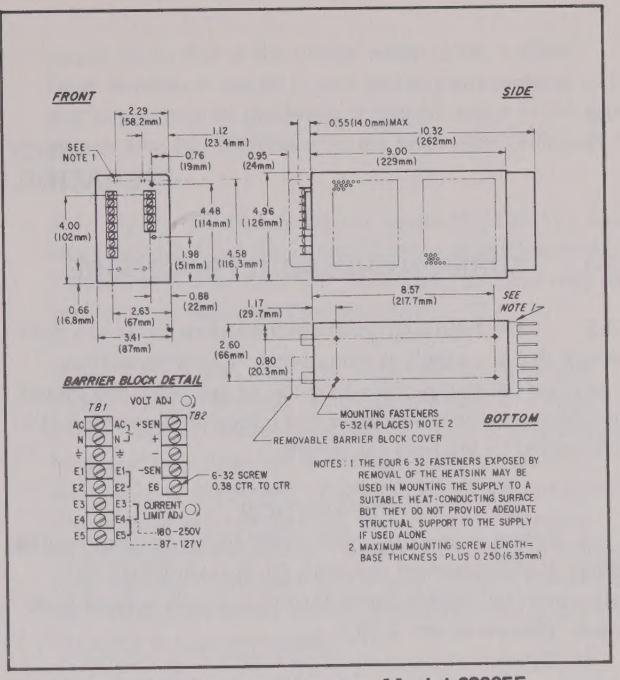

FRONT
SIDE
BARRIER BLOCK DETAIL
BOTTOM
MOUNTING FASTENERS
6-32 (4 PLACES) NOTE 2
REMOVABLE BARRIER BLOCK COVER
NOTES: 1 THE FOUR 6 32 FASTENERS EXPOSED BY REMOVAL OF THE HEATSINK MAY BE USED IN MOUNTING THE SUPPLY TO A SUITABLE HEAT-CONDUCTING SURFACE BUT THEY DO NOT PROVIDE ADEQUATE STRUCTUAL SUPPORT TO THE SUPPLY IF USED ALONE
2 MAXIMUM MOUNTING SCREW LENGTH= BASE THICKNESS PLUS 0.250 (6.35mm)

Figure 2-3. Outline Diagram, Model 63005E

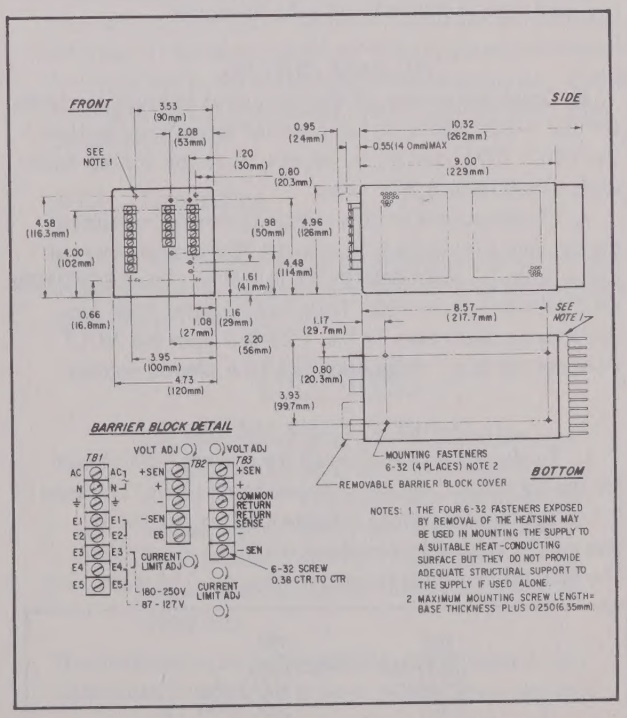

FRONT
SIDE
BARRIER BLOCK DETAIL
BOTTOM
MOUNTING FASTENERS
6-32 (4 PLACES) NOTE 2
REMOVABLE BARRIER BLOCK COVER
NOTES: 1 THE FOUR 6-32 FASTENERS EXPOSED BY REMOVAL OF THE HEATSINK MAY BE USED IN MOUNTING THE SUPPLY TO A SUITABLE HEAT-CONDUCTING SURFACE BUT THEY DO NOT PROVIDE ADEQUATE STRUCTURAL SUPPORT TO THE SUPPLY IF USED ALONE.
2 MAXIMUM MOUNTING SCREW LENGTH= BASE THICKNESS PLUS 0.250(6.35mm).

Figure 2-4. Outline Diagram, Model 63315E

SECTION III
OPERATING INSTRUCTIONS

3-1 TURN-ON CHECKOUT PROCEDURE

3-2 The following checkout procedure serves as a brief check that the supply is operational. This procedure or the more detailed performance test of paragraph 5-6 should be followed when the instrument is received and before it is connected to any load equipment.

PREPARATION

a. Before connecting input power to the ac-input models, check that jumpers on terminals E1 through E5 of TB1 are connected appropriately for the ac supply voltage to be used. (See paragraph 2-16.)

b. Connect all remote sensing terminals to the corresponding output terminals as shown in Figure 3-1.

c. Connect unit to input power source. Use the AC, N, and ground (⏚) terminals on an ac-input unit or the (+), (—), and ground terminals on a dc-input unit.

VOLTAGE CHECKS

d. Check the voltage of the 5V output between terminals (+) and (—) on TB2 and, using a small screwdriver to turn the VOLT ADJ control, set the output to the desired value within its 4.75 to 5.25V range.

e. (Triple-output models only.) Check the voltages of the positive and negative 11.4 to 15.75V outputs by measuring from (+) to COMMON RETURN and from COMMON RETURN to (—) on TB3. They should differ from each other by no more than (±1% +20mV.) Turn the VOLT ADJ control to set these outputs to the desired voltage.

CURRENT LIMIT CHECKS

f. To check the operation of the current limit circuit for the 5V output, connect the test setup shown in Figure 5-2 to the output, using a variable load resistor for R_L that can be adjusted from about 0.15Ω to about 0.5Ω. The load resistor must be able to dissipate 110 watts. Set R_L to its maximum resistance and apply power to the supply. Decrease the resistance of R_L gradually while observing the output current indicated by the DVM. The current should increase to some maximum value, which is the current limit setting, and then begin to decrease. To adjust the current limit setting, see paragraph 5-46.

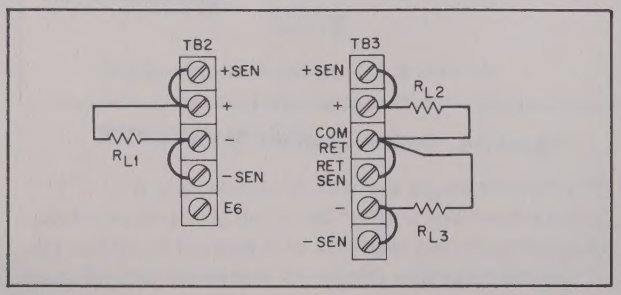


Figure 3-1. Load Connections, Local Sensing

g. (Triple-output models only.) Check the operation of the current limit circuit for the positive 11.4 to 15.75V output by the method described in (f) above, but using a variable load resistor with an adjustment range of about 4Ω to 15Ω and a 50W power rating. Repeat for the negative output. To adjust the current limit settings, see paragraph 5-46.

OVERVOLTAGE PROTECTION CHECKS

h. Because the supply's output voltage adjustment ranges are limited and the overvoltage trip circuits are not adjustable, checking the overvoltage trip circuits requires the use of an external power supply. The supply needed for checking the overvoltage trip for the 5V output should be able to supply 5 to 7Vdc at a current of at least 2 amps. To avoid causing damage to the supply under test, the external supply's maximum available current should be no more than 5 amps. To check that the overvoltage trip circuit for the 5V output is operational, energize the external supply and adjust its outputs to 6.5 volts. Energize the supply being tested and then momentarily connect the output of the external supply across its 5V output terminals, negative to negative and positive to postive. After disconnecting the external supply, check for the presence of voltage at the outputs of the supply under test. All outputs should be at zero volts. Deenergize the supply under test for 10 seconds and then restore power. Check that all outputs have returned to normal.

i. (Triple-output models only.) A similar method is used for checking the ±11.4 to ±15.75V outputs of the triple-output models. An external supply is needed that can provide 15 to 18Vdc at a current of at least 0.5 amps. Its maximum available current should be no more than 2 amps. To check the overvoltage trip circuit for the positive 11.4 to 15.75V output, energize the external supply and adjust its output to 18 volts. Energize the supply being tested and then momentarily connect the output of the external supply across its (+) and COMMON RETURN output terminals, positive to positive. After disconnecting the external supply, check that all outputs of the supply under test have dropped to zero volts and that deenergizing the supply for 10 seconds restores the outputs to normal.

j. (Triple-output models only.) To check the overvoltage trip circuit for the negative 11.4 to 15.75V output, repeat the procedure given in step (i) above, except connect the external supply across the (—) and COMMON RETURN output terminals of the supply under test, negative to **negative, positive to common return.**

REMOTE SHUTDOWN

k. Verify that connecting a jumper between terminals E6 and (—SEN) on TB2 reduces the supply's output voltage(s) to a low level and that disconnecting the jumper restores all output voltages to normal.

3-3 If this brief checkout procedure or later use of the supply reveals a possible malfunction, see Section V of this manual for detailed test, troubleshooting, and adjustment procedures.

3-4 OPERATION

——— CAUTION ———

Before applying power to one of the ac-input models, make certain that jumpers E1 through E5 on TB1 are connected appropriately for the ac line voltage to be used. (See paragraph 2-16.)

3-5 The following paragraphs discuss the various operating modes and features of the Models 61005E, 61315E, 63005E, and 63315E. Their 5V outputs can be used with local or remote voltage sensing. The ±11.4 to ±15.75V outputs of the triple-output models can be used as a dual output supplying equal positive and negative voltages, or they can be connected to provide a single 22.8 to 31.5-volt output. Local or remote sensing can be used with either the dual or single load connections.

3-6 The DC Power Supply Handbook, Application Note 90A, is a useful source of additional information on using regulated power supplies effectively. This 138-page handbook includes chapters on operating principles, ac and load connections, optional operating modes, and performance measurements and is available at no charge from your local HP sales office. The address of your local sales office can be found in the back of this manual.

3-7 Connecting Loads

3-8 Figure 3-1 shows the strapping arrangement for connecting loads to the supply using local voltage sensing and supplying two separate loads from the ±11.4 to ±15.75V outputs. The positive (master) supply powers R_{L2} and the negative (slave) supply powers R_{L3}. As the VOLT ADJ control for the dual outputs is adjusted, the slave supply's output tracks that of the master within ±1% +20mV. Either terminal of the 5V output and any one terminal of the dual output may be grounded, if desired, either at the supply's ground (⏚) terminal or at the load. (See paragraph 3-12.)

3-9 To use the dual outputs to supply 22.8 to 31.5 volts to a single load, use the strapping arrangement shown in Figure 3-2. Either the (+) or (—) output terminal may be grounded, as required. (See paragraph 3-12.)

3-10 Each load should be connected to the proper supply output terminals using separate pairs of connecting wires. This will minimize mutual coupling effects between loads and will retain full advantage of the low output impedance of the supply. Each pair of connecting wires should be as short as possible, should be of adequately heavy gauge, and should be twisted or shielded to reduce noise pickup. If shielded wire is used, connect one end of the shield to the power supply ground terminal and leave the other end unconnected.

3-11 If load considerations require that the output power distribution terminals be remotely located from the power supply, then the power supply output terminals should be connected to the remote distribution terminals by a pair of twisted or shielded wires and each load separately connected to the remote distribution terminals. Remote sensing should be used under these circumstances. (See paragraph 3-14.)

3-12 Grounding

3-13 The 5V output can be used either as a positive or a negative supply by grounding one of its output terminals or one end of the load.

WARNING

Ground at only one point in the setup and always use two wires to connect the load to the supply. This eliminates the possibility of load current return paths through the input ground line which could open the chassis ground path and create a hazardous condition.

If neither output bus is grounded, the outputs of this supply can be operated at up to 42Vdc above ground.

3-14 Remote Sensing

3-15 Remote sensing is used to maintain good regulation at the load by reducing the degradation in regulation that would occur due to the voltage drop in the leads between the power supply and the load. For reasonable load lead

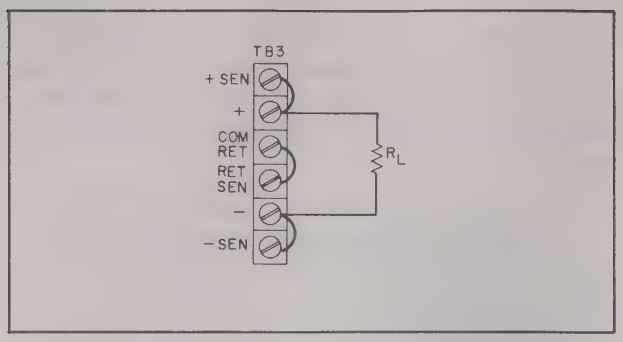


Figure 3-2. Single Load, Local Sensing

lengths, remote sensing greatly improves the performance of the supply. However, if the load is located a considerable distance from the supply, added precautions must be observed to obtain satisfactory operation.

3-16 Because the voltage drop in the load leads subtracts directly fromthe available output voltage, it is recommended that the total drop in both load leads not exceed 5% of the supply's nominal output voltage. The leads from the sensing terminals to the load carry much less current than the load leads, so these leads need not be as heavy as the load leads. However, they must be twisted or shielded to minimize noise pickup.

3-17 Figure 3-3 shows the strapping arrangement for connecting loads to the supply using remote sensing. When the loads on the dual outputs of a triple-output model are located a considerable distance from each other, the COMMON RETURN load lead and the RETURN SENSE lead should be connected together at a remote sensing point that is equidistant from the two loads. This ensures that the regulation characteristics of both outputs will be equal.

3-18 Figure 3-4 shows the connections necessary for powering a single load from the dual output using remote sensing. The (+SEN) and (–SEN) sensing leads should be connected as close as possible to the load.

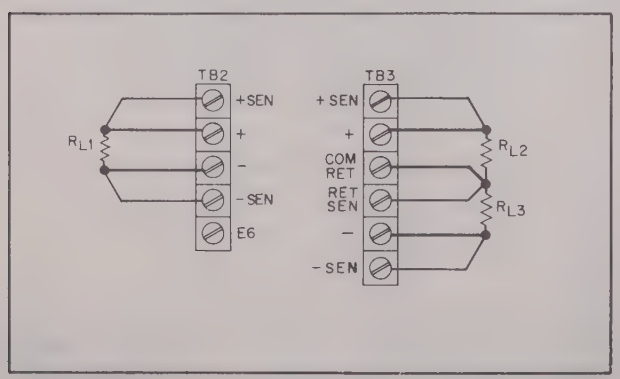


Figure 3-3. Load Connections, Remote Sensing

3-19 Output Ratings

3-20 Models 61005E and 63005E. These single-output models are capable of providing 22 amps at 5V ±0.25V at ambient temperatures up to 40°C. Above 40°C, the output current must be linearly derated to 50% at the maximum operating temperature of 70°C.

3-21 Models 61315E and 63315E. Individually, the maximum output currents of these triple-output models are 18 amps at the 5V ±0.25V output and 2 amps at each of the 11.4 to 15.75V outputs. These maximum currents are not available simultaneously, though, due to the 110W total output rating of the supply. Figure 3-5 illustrates the load sharing tradeoff between the 5V and the ±11.4 to ±15.75V outputs. Above 40°C, these output currents must be linearly derated to 50% at the maximum operating temperature of 70°C.

3-22 Current Limiting

3-23 The current limiting characteristics of these supplies are shown in Figures 3-6 and 3-7. The current limit circuits in these supplies provide foldback limiting, which reduces the output current as the voltage decreases. This results in a short-circuit current that is less than the maximum available at the rated output voltage. The circuits are self-restoring and return the output voltage to normal when the overload is removed. Figures 3-6 and 3-7 show the approximate factory settings and adjustment ranges for the current limiting circuits. Changing the setting of the control affects the maximum output current as shown but has no effect on the short circuit current. Procedures for adjusting the operating points of the current limit circuits are given in paragraph 5-46.

3-24 When adjusting the current limit, ensure that the new set point is at least 10% above the expected operating current. Operating the supply too close to the current limit set point may degrade performance.

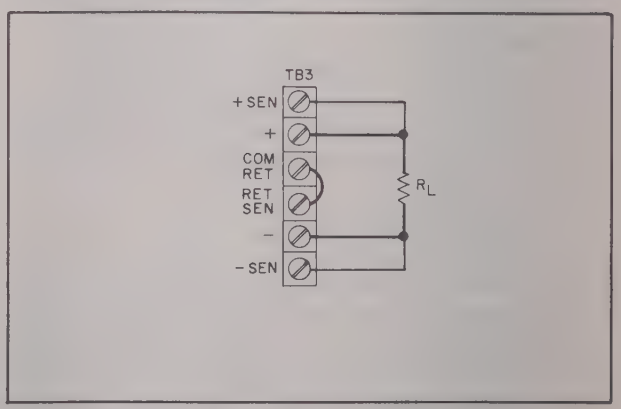


Figure 3-4. Single Load, Remote Sensing

3-25 Since, in the dual outputs of the triple-output models, the voltage of the slave (negative) supply depends on that of the master (positive) supply, the occurrence of current limiting in the master supply reduces the voltage of both outputs. If a single load is connected across both outputs as shown in Figures 3-2 and 3-4, the initial current limit point is determined by the current limit circuit with the lower setting and the short circuit current is governed by the master supply.

3-26 Overvoltage Protection

3-27 Each output of this supply has an independent fixed crowbar circuit to protect sensitive loads from excessive voltages. The circuit for the 5V output is activated between 5.9 and 6.5 volts and the ones for the dual outputs of the triple-output models are activated between 16.1 and 17.9 volts. After a crowbar circuit fires, all outputs of the supply fall to zero volts. To restore normal operation after an overvoltage shutdown has occurred, ac power must be removed from the supply for at least 10 seconds. If the crowbar trips again when power is restored, refer to the troubleshooting information in Section V of this manual.

3-28 Remote Shutdown

3-29 If remote control of the power supply is required, all outputs of the supply can be operated remotely through a contact connected from terminal E6 on TB2 to either the (–) or the (–SEN) terminal of the 5V output. Closing this contact reduces all outputs to a low level.

3-30 The remote shutdown input can also be controlled by a TTL digital input signal. Use the (–) or (–SEN) terminal of the 5V output as the common input and apply TTL logic levels to terminal E6. A low logic level shuts down the supply; a high logic level input restores the outputs.

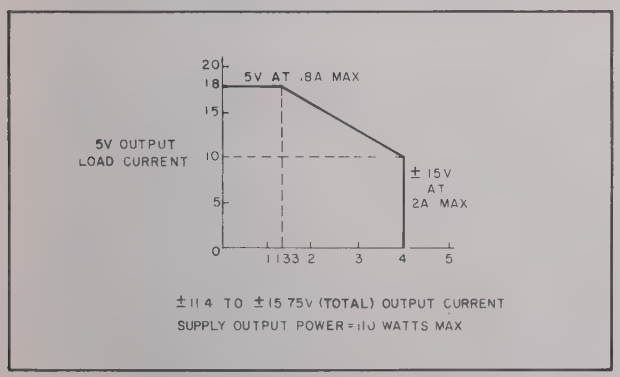


Figure 3-5. Load Sharing Tradeoff, Models 61315E and 63315E

3-31 Series Operation

3-32 Either the 5V or the ±11.4 to ±15.75V outputs of two or more supplies can be connected in series to obtain a higher voltage than is available from a single supply. The number that can be connected in series is limited by the restriction against operating these supplies with their outputs at a potential greater than 42 volts above ground.

3-33 Notice that series operation creates the possibility of a reverse voltage being applied across the output terminals of a deenergized supply that is in series with an energized one. If this occurs, the resulting reverse current flows through A2U2 in a 5V output or diodes A3CR1 or CR2, which protect the ±15V outputs against reverse voltage. These diodes provide reverse voltage protection at currents up to the current rating of the respective power supply output.

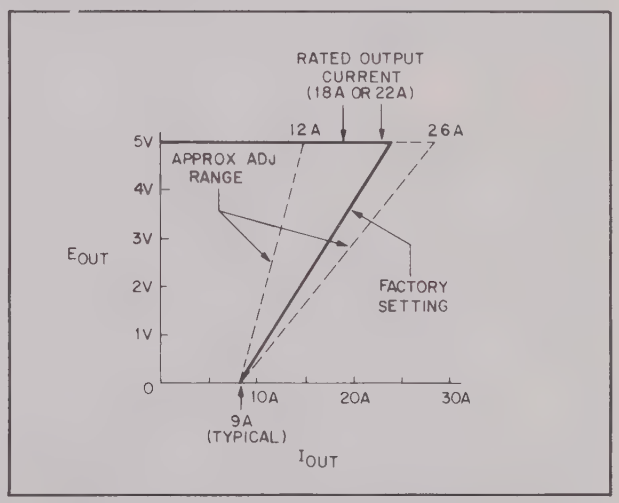


Figure 3-6. 5V Output, Current Limit Characteristics

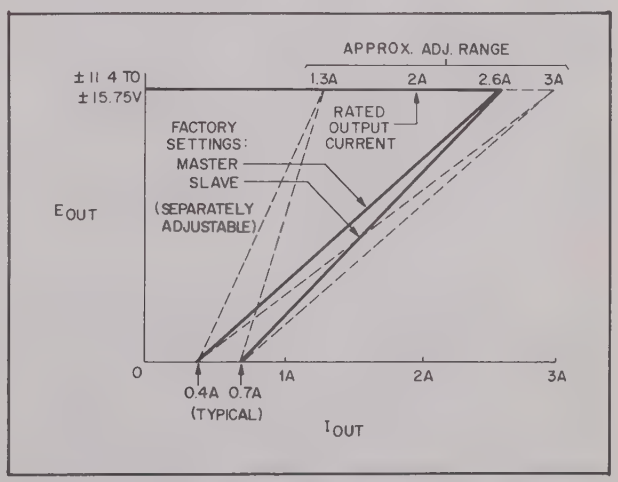


Figure 3-7. Models 61315E and 63315E, Dual Output, Current Limit Characteristics

SECTION IV
PRINCIPLES OF OPERATION

4-1 INTRODUCTION

4-2 The four power supply models included in this manual are composed of four different combinations of the circuit boards shown in the simplified schematic of Figure 4-1. The single-output models each use two circuit boards. The dc-input Model 61005C uses the A1 board shown at the upper left of the figure along with the A2 board at the upper right, and the ac-input Model 63005C uses the A1 board at the lower left and the same A2 board. The two triple-output models, the dc-input 61315D and the ac-input 63315D, each add the A3 board shown at the lower right to the pair of boards used in the corresponding single-output model.

4-3 The A1 board used in the dc-input models contains an LC filter, a 20kHz switching regulator, and an input overvoltage comparator that protects the regulator from an excessive input voltage by turning off the clock that times its operation. The regulator's control signals are received from the A2 board. An output overvoltage trip signal, also received from the A2 board, shuts down the regulator by removing power from the clock.

4-4 The A1 board used in the ac-input models contains an input RFI filter and an SCR preregulator whose 106-volt dc output provides input power to a 20kHz switching regulator. The switching regulators used in the dc-input and the ac-input models are similar. In both circuits, a recurrent pulse signal from the clock turns on a switching transistor connected in series with the primary of a transformer located on the A2 board. Following each turn-on pulse, a pulse received from a pulse-width modulator on the A2 board turns off the transistor. The switching transistor remains turned-off until the next clock pulse turns it on again. The pulse-width modulator controls the duration of the switching transistor's conduction time to regulate the 5-volt dc output of the supply.

4-5 On the A2 board, the 20kHz output from the switching regulator transformer secondary is rectified and filtered to produce the supply's 5-volt regulated dc output. Circuits on the A2 board provide input signals to the pulse-width modulator that enable the modulator to regulate the output voltage, limit the output current, and turn on the power supply output(s) gradually when input power is first applied. A photo-isolator on the A1 board couples the pulse-width modulator's output pulses to the switching regulator. The A2 board also includes an overvoltage protection crowbar circuit for the 5-volt output. When this circuit detects an output overvoltage, it shorts the output and sends an overvoltage trip pulse to the clock shutdown switch on the A1 board.

4-6 The A3 board is used only in the triple-output models. This board contains two linear transistor series regulators connected in a positive-and-negative master-slave configuration. The negative supply uses the positive output as its reference voltage so that both outputs track within ±1% +20mV as they are varied over their ±11.4 to ±15.75-volt range by a single screwdriver adjustment. The 20kHz outputs from two additional secondary windings on the switching regulator transformer are rectified and filtered to provide the dc inputs to these series regulators. Each regulator is equipped with output current limit and overvoltage protection crowbar circuits. The overvoltage circuits on the A3 board generate a trigger that trips the clock shutdown switch on the A1 board to turn off the switching regulator when an overvoltage condition occurs. Turning off the switching regulator reduces the voltage at all three outputs to zero.

4-7 SIMPLIFIED SCHEMATIC DIAGRAM DISCUSSION

4-8 The following discussion of the overall operation of these power supplies is based on the simplified schematic of Figure 4-1. For detailed circuit information, refer also to Figures 7-4, 7-6, 7-8, and 7-9.

4-9 DC-DC Converter (A1 Board, Models 61005E and 61315E Only)

4-10 A normally back-biased diode connected across the input of the dc-input A1 board blows the input fuse to protect the regulator from being damaged by the application of a wrong polarity input. The regulator is also protected against an excessive input voltage by an input overvoltage comparator circuit that turns off the switching regulator by sending a reset signal to the 20kHz clock if the input exceeds 64 volts. When the input voltage returns to within normal limits, normal operation resumes automatically. Dc input power is filtered by an LC filter and applied to the 20kHz switching regulator.

4-11 **20kHz Switching Regulator.** The supply's 5V

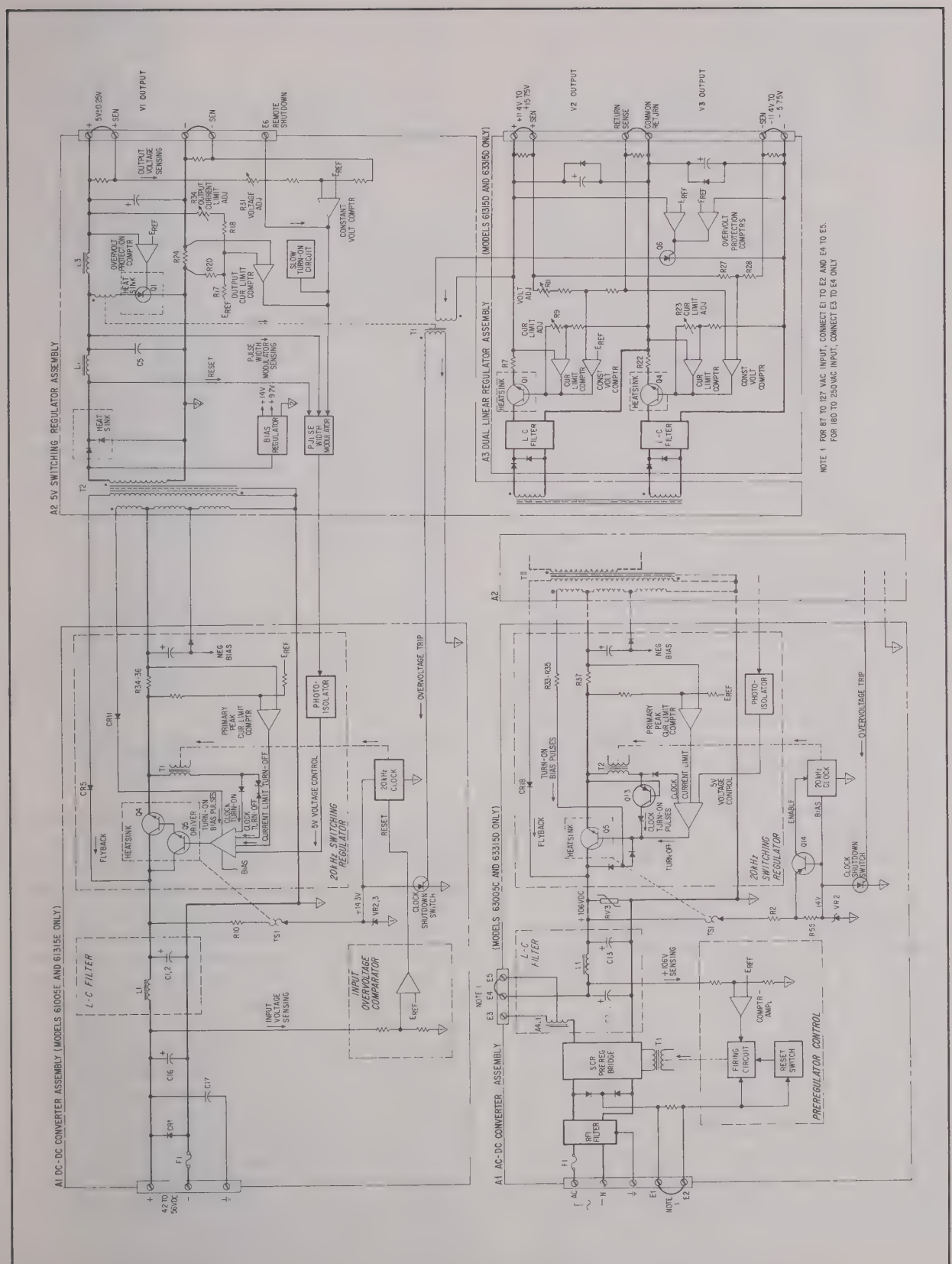

A1 DC-DC CONVERTER ASSEMBLY (MODELS 61005E AND 61315E ONLY)
A2 5V SWITCHING REGULATOR ASSEMBLY
A3 DUAL LINEAR REGULATOR ASSEMBLY (MODELS 61315D AND 63315D ONLY)
A1 AC-DC CONVERTER ASSEMBLY (MODELS 63005E AND 63315D ONLY)
V1 OUTPUT
V2 OUTPUT
V3 OUTPUT
L-C FILTER
20kHz SWITCHING REGULATOR
PREREGULATOR CONTROL
INPUT OVERVOLTAGE COMPARATOR
NOTE 1 FOR 87 TO 127 VAC INPUT, CONNECT E1 TO E2 AND E4 TO E5.
FOR 180 TO 250 VAC INPUT, CONNECT E3 TO E4 ONLY

Figure 4-1. Simplified Schematic Diagram, Models 61005E, 61315E, and 63315E

output is regulated by a transistor switching regulator connected in series with the 42 to 56-volt dc input source and the primary winding of power transformer A2T2 on the A2 board. The 5V output is regulated by controlling the percentage of the time that switching transistor A1Q4 conducts. An IC timer in the 20kHz clock circuit controls the transistor's switching rate, and a pulse width modulator located on the A2 board controls its on-time.

4-12 The clock establishes the basic timing cycle for the regulator by generating an alternating sequence of switching transistor turn-on and turn-off pulses that are conducted to the base of A1Q4 through pulse transformer A1T1. The maximum duty cycle of the switching transistor is 60%. Each time that a turn-on clock pulse switches A1Q4 on, a turn-on bias pulse produced by a regenerative bias winding of A2T2 keeps A1Q4 on until a turn-off signal appears.

4-13 Following each clock turn-on pulse, there are three signals that can turn off the switching transistor. They are:

(1) a voltage control pulse from the pulse width modulator,

(2) a primary peak current limit pulse from a current limit comparator in the switching regulator,

(3) a turn-off pulse from the clock.

The first of these three signals to appear after each clock turn-on pulse turns A1Q4 off until the next clock turn-on pulse initiates the next operating cycle.

4-14 Normally, it is the voltage control pulse that turns off A1Q4. An optically coupled isolator in its signal path provides electrical isolation between primary and secondary circuits. The timing of this pulse controls the voltage of the 5V output. A tendency for the output voltage to decrease is compensated by an increase in the delay between the clock turn-on pulse and the subsequent turn-off pulse from the pulse width modulator. If the output tends to increase, the delay is reduced. Slow turn-on control, output current limit, and remote shutdown signals are also communicated through this path from the A2 board. The generation of these signals is covered in the discussion of the A2 board.

4-15 The second switching transistor turn-off signal listed in paragraph 4-13 is produced by a fixed current limit comparator that monitors the peak current through A1R34 through A1R36 during each pulse that A1Q4 conducts and immediately turns off A1Q4 if this current exceeds a preset level. This current limit circuit on the primary side of the transformer serves as a backup to the protection provided by an adjustable output current limit circuit on the secondary side. The primary peak current limit circuit has a higher set point than the one on the secondary side and functions solely to protect the switching transistor.

4-16 The third turn-off signal listed in paragraph 4-13, the clock turn-off pulse, limits the maximum on-time of A1Q4 to 30 microseconds of each 50μsec operating cycle to avoid transformer saturation.

4-17 Between the time a turn-off signal ends A1Q4's conduction interval and the time the clock turn-on pulse turns A1Q4 on again, the collapsing field of transformer A2T2 generates a current pulse in a flyback winding which CR5 conducts to return this energy to capacitors A1C1 and A1C2 at the input to the switching regulator. This keeps the transformer core out of saturation by resetting it before the next operating cycle begins.

4-18 The clock receives its +14.3V operating bias from a shunt zener regulator composed of R10, VR2, and VR3. An excessive A1Q4 switching transistor heatsink temperature opens thermal switch TS1 to interrupt the dc supply to the clock bias regulator. This stops the clock to leave A1Q4 safely turned off. TS1 remains open until the heatsink has cooled to a safe operating temperature.

4-19 In case of an overvoltage condition at the 5V output of one of the single-output models or at any of the outputs of a triple-output model, an overvoltage trip pulse fires an SCR connected as a clock shutdown switch that shorts the 14.3V bias supply to the clock to shut down the switching regulator.

4-20 AC-DC Converter (A1 Board, Models 63005E and 63315E Only)

4-21 The 20KHz switching regulator circuits in the dc-input models are similar to those in the ac-input models with one exception. This is the addition of Q13 which insures that switching transistor Q5 can be turned completely off by isolating the base of Q5 from any leakage current generated by A1T2. In the ac-input models, the dc input to the switching regulator is provided by an SCR preregulator that converts an ac input of 87 to 127 volts or 180 to 250 volts to a regulated 106 volts dc.

4-22 Preregulator. The ac input to the A1 board is connected through an RFI filter. This filter aids in the reduction of EMI that could be conducted back into the ac line. It also prevents surge voltages from entering the preregulator bridge which could damage the SCR's and misfire the preregulator. The preregulator bridge is composed of two diodes and two SCR's. The firing angle of the SCR's is controlled by the preregulator control circuit so that their full-wave rectified output, after being filtered by an L-C filter, averages 106 volts dc. Following the L-C filter is a varistor

RV3 that keeps the preregulator's output from exceeding approximately 190 volts. This abnormal and non-destructive surge could occur due to extremely high common-mode spikes present on the power line. The preregulator control circuit consists of a comparator-amplifier that compares the voltage at its input to a zener reference voltage and controls the firing delay of a programmable unijunction transistor in the firing circuit. During each half-cycle of the ac line input one output pulse from the unijunction is coupled to the SCR gates by pulse transformer A1T1. If the 106V output tends to increase, the comparator-amplifier reduces the conduction angle of the SCRs. If the voltage tends to decrease, the conduction angle is increased. The reset switch discharges the timing capacitor in the firing circuit at the end of each half-cycle of the ac line input.

4-23 As the voltage from the preregulator bridge charges filter capacitors A1C2, C3, and C13 to approximately 60 volts, Q14 will become foward biased providing a reset signal to the 20KHz clock thus enabling it to start. This action prevents the clock from starting before the preregulator output voltage reaches a safe level. Q11 and Q12 in the clock circuit are buffers connected in a stacked configuration. They insure sharp positive and negative output transtions from the clock (See Figure 7-6).

4-24 The supply is designed for two ac line voltage ranges (87 to 127Vac and 180 to 250Vac) and can easily be converted from one to the other by changing jumper positions on terminals E1 through E5 on an external terminal block.

4-25 5V Switching Regulator Assembly (A2 Board)

4-26 On the A2 board, the 20kHz ac voltage at one secondary of switching regulator power transformer A2T2 is half-wave rectified and then filtered by a 2-section LC filter to provide a regulated 5V dc output. This board also contains circuits that regulate the output voltage, turn on the switching regulator slowly when power is first applied, limit the output current, and shut down the supply if an overvoltage occurs at the 5V output. The output voltage regulation, slow turn-on, and output current limit functions are controlled through input signals to the pulse width modulator, whose output is transmitted through the optically coupled isolator on the A1 board to the switching regulator transistor.

4-27 **Voltage Regulation.** Each output pulse from the pulse width modulator causes the switching regulator transistor to stop conducting. Thus, the output voltage is regulated by controlling the duration of this transistor's conduction intervals. The pulse width modulator controls the timing of its output pulses by comparing two input signals. One of them is a dc level received from the output of the constant voltage comparator. This signal varies with the difference between the supply's output voltage and that of a fixed reference. An increase in the supply's output voltage changes this dc level in the negative direction. The pulse width modulator compares this dc level to a combined dc and ripple signal taken from the output of the first section of the LC filter.

4-28 When the clock on the A1 board turns the switching regulator transistor on, the positive voltage at the secondary of transformer A2T2 begins charging A2C5 through inductor A2L1. The positive-going ramp voltage waveform on these capacitors and the dc level from the constant voltage comparator are both attenuated and applied to two inputs of a comparator within the pulse width modulator. The pulse width modulator's output pulse to the isolator is produced each time the dc plus ripple voltage input from A2C5 exceeds the dc level input from the constant voltage comparator. The input pulse to the isolator turns on a light emitting diode (LED) which turns on a phototransistor. When the phototransistor conducts, it turns off the switching regulator transistor.

4-29 Now that the switching regulator transistor has been turned off, the negative-going voltage at the input to inductor A2L1 resets the pulse width modulator for the next operating cycle, which begins when the clock turns on the transistor again.

4-30 If the voltage at the 5V output tends to decrease, the dc level input to the pulse width modulator increases. As a result, it takes slightly longer for the ramp waveform of the ripple voltage to exceed this higher dc level at the comparator inputs. Thus, the delay before the switching regulator transistor is turned off is increased slightly to increase its conduction time and compensate for the decreased output.

4-31 **Slow Turn-On Control.** The slow turn-on control circuit prevents an output voltage overshoot from occuring and actuating the overvoltage trip circuit when power is first applied to the supply. The circuit consists of an r-c network that slows down the initial rise in voltage of the dc level input to the pulse width modulator from the constant voltage comparator. This causes the switching regulator to bring up the output voltage smoothly to its nominal value.

4-32 **Output Current Limiting.** The 5V output is protected against an overload or short circuit by an adjustable foldback current limit circuit that reduces the output voltage and current as an overload increases. The current limit characteristics of the 5V output are shown in Figure 3-6. To obtain these current limit characteristics

the output current limit comparator compares the voltage developed across current sampling resistor R24 to a reference voltage developed across R20. When the voltage across R24 exceeds this reference, the output of the comparator reduces the dc level input to the pulse width modulator to reduce the supply's output. The resulting reduction in output voltage decreases the contribution made to the reference voltage across R20 by current from the positive output line through R34 and R18. This reduces the output current limiting point as the output voltage decreases. If the output is short-circuited, the circuit reduces the output current to the value determined by the reference voltage developed by the current through R17 alone. For this reason, output current limit adjust R34 affects the maximum output current while leaving the short-circuit current fixed.

4-33 Remote Shutdown. A contact closure or TTL input signal applied between remote shutdown terminal E6 and either the negative output or the negative sensing terminal of the 5V supply reduces all outputs of the supply to a low level. This input signal shuts down the outputs by lowering the dc level input to the pulse width modulator. The outputs of the supply return to normal on removal of the remote shutdown input signal.

4-34 Overvoltage Protection. An overvoltage protection circuit monitors the 5V output and fires SCR A2Q1 if the voltage exceeds a preset trip level of 5.9 to 6.5 volts. When A2Q1 fires, it immediately discharges the filter capacitors across the 5V output to reduce the output to less than 2 volts. At the same time, a current pulse from A2T1 fires the clock shutdown switch SCR on the A1 board to remove power from the clock and shut off the switching regulator transistor. This reduces all output voltages to zero. In order to restore the supply to operation, its input power must be removed for a minimum of 10 seconds and then reapplied.

4-35 Dual Linear Regulator Assembly (A3 Board, Models 61315E and 63315E Only)

4-36 Two series-transistor regulators on the A3 board provide dual tracking outputs of ±11.4 to ±15.75 volts. The input power to these regulators is obtained from two additional secondary windings of transformer A2T2 and is half-wave rectified and filtered on the A3 board.

4-37 Voltage Regulation. The regulators for the positive and negative outputs are similar except that the one for the positive output compares its output voltage to that of a zener reference while the one for the negative output compares the voltage at the COMMON RETURN output terminal to the voltage at the junction of two equal resistors, A3R27 and A3R28, which are connected across the positive and negative outputs. This is why the output voltage of the negative (or slave) supply matches that of the positive (or master) supply within a ±1% +20mV tolerance and a single voltage adjustment control, A3R11, controls both outputs. The constant voltage comparators regulate the outputs of the supply by controlling the conductance of series regulator transistors A3Q1 and A3Q4.

4-38 Output Current Limiting. A current limit comparator for each regulator monitors the voltage drop across current sampling resistor R7 or R22 and compares it to an adjustable reference voltage across R9 or R23 that is derived from the regulator's output. If the voltage drop across the current sampling resistor exceeds the reference voltage, the comparator's output signal to the series regulator causes the output voltage and current to be reduced. This reduction in the output voltage reduces the current limit circuit's reference voltage to produce the foldback current limit characteristic shown in Figure 3-7. Because of the dual tracking interconnection between the positive and negative supplies, the output voltages of both are reduced if the positive output is overloaded.

4-39 Overvoltage Protection. To protect loads on the ±15V outputs against overvoltage, an overvoltage protection comparator monitors each output and fires an SCR connected across the ±15V outputs if either exceeds the preset trip level of 16.1 to 17.9 volts. When SCR A3Q6 fires, it shorts the ±15V outputs and simultaneously sends an overvoltage trip pulse through A2T1 to the clock shutdown switch on the A1 board to shut down the clock. Thus an overvoltage condition at any of the triple output supply's three outputs shuts down the entire supply.

SECTION V
MAINTENANCE

5-1 INTRODUCTION

5-2 Upon receipt of the power supply, the performance test of paragraph 5-6 can be made. This test is suitable for incoming inspection. Section III contains a quick but less comprehensive checkout procedure that can be used in lieu of the performance test if desired.

5-3 If a fault is detected in the power supply while making the performance test or during normal operation, proceed to the troubleshooting procedure in paragraph 5-33. After troubleshooting and repair, repeat the performance test to ensure that the fault has been properly corrected and that no other faults exist.

5-4 TEST EQUIPMENT REQUIRED

5-5 Table 5-1 lists the test equipment required to perform the various procedures described in this section.

Table 5-1. Test Equipment Required

TYPE	REQUIRED CHARACTERISTICS	USE	RECOMMENDED MODEL
Digital Voltmeter	Sensitivity: 100μV full scale (min.). Input Impedance: 10 megohms (min.).	Measure DC voltages: calibration procedures	HP 3450A
Variable Voltage Transformer	Range: 90-130Vac Equipped with voltmeter accurate within 1 volt	Vary AC input	– – – –
Oscilloscope	Sensitivity: 5mV/cm. Bandwidth: 20MHz (min.) Differential input	Display transient response and ripple and noise waveforms.	HP 180A with 1821A, and 1801A or 1803A plug-ins.
Multimeter	±2% DC accuracy	Resistance checks.	Simpson Model 269
Repetitive Load Sw.	Rate: 60Hz, 2μsec rise and fall time.	Measure transient response.	See Figure 5-4.
Resistive Loads	Tolerance: ±5%.	Power supply load resistor (fixed resistor or rheostat).	James G. Biddle ("Lubri-Tact" Rheostat).
Current Sampling Resistor (Shunt)	Accuracy: 1%	(a) Measure 5V output current. (b) Measure ±15V output current	(a) Empro Shunt, A-50-50. (b) 0.1Ω resistor, HP Part No. 0811-2061.
Regulated dc power supply	Adjustable output, 5 to 20Vdc at 2A (min.). Current limited to 5A or less.	Output overvoltage protection checks (para. 3-2).	– – – –
Variable dc power supply	Adjustable from 40 to 70Vdc at 0 to 6A (min.).	Source effect and input overvoltage testing of dc-input models.	– – – –

5-6 PERFORMANCE TEST

5-7 The following test can be used as an incoming inspection check and appropriate portions of the test can be repeated to check the operation of the instrument after repairs. The tests are performed using the specified nominal input voltage for the unit. If the correct result is not obtained for a particular check, proceed to troubleshooting (paragraph 5-33).

CAUTION

Before applying power to either of the ac-input models, make certain that jumpers E1 through E5 on TB1 are connected appropriately for the ac line voltage to be used (see paragraph 2-16).

5-8 General Measurement Techniques

5-9 Connecting Measuring Devices. To achieve valid results when measuring the load effect, PARD (ripple and noise), and transient recovery time of the supply, measuring devices must be connected across the supply's sensing terminals. If a measurement were made across the load, it would include the impedance of the leads to the load. This impedance can easily be several orders of magnitude greater than the supply impedance, and would thus invalidate the measurement. To avoid mutual coupling effects, each measuring device must be connected directly to the supply's sensing terminals by separate pairs of wires.

5-10 Output Current Measurements. Accurate output current measurements can be made by inserting a low resistance current sampling resistor in series with a load resistor of appropriate resistance and wattage. Table 5-1 recommends two four-terminal resistors suitable for use as current sampling resistors for the 5V and ±15V outputs. Figure 5-1 shows a four-terminal meter shunt. The load current through a shunt must be fed to the extremes of the wire leading to the resistor while the sampling connections are made as close as possible to the resistance portion itself.

NOTE

Output current limiting would interfere with accurate measurements of the supply's performance. Avoid current limiting by making certain that the current limit adjustments are set sufficiently above the rated output current (see paragraph 3-24).

5-11 Rated Output Checks

5-12 To check that the supply will furnish its rated output voltage(s) and current(s), proceed as follows

a. Connect in series across the (+) and (—) terminals of the 5V output a suitable load resistor, a current sampling resistor, and a switch, as shown in Figure 5-2. The load resistor must be of the proper value and of adequate wattage to draw full rated current from the 5V output.

b. Connect a digital voltmeter across the (+SEN) and (—SEN) terminals of the 5V output, observing correct polarity.

c. Apply input power to the supply and, with the load switch open, set the voltage of the 5V output to any desired value within the adjustment range. This output voltage can be used for all remaining 5V performance tests.

d. Connect the voltmeter across the current sampling terminals of the current sampling resistor, close the load switch, and adjust R_L until the voltmeter indicates a voltage drop corresponding to the 5V output's maximum rated current.

e. Reconnect the voltmeter across the (+SEN) and (—SEN) terminals of the 5V output and recheck its output voltage. It should be within 0.04% +3mV of the value set in step (c).

f. Steps (f) and (g) apply only to the triple-output models. Use the same procedure described in steps (a) through (e) above to check the +11.4 to +15.75V output. Connect a switch, a load resistor of appropriate value, and a current sampling resistor in series between the (+) and the COMMON RETURN terminals and monitor the output voltage across the (+SEN) and RETURN SENSE terminals.

g. Check the —11.4 to —15.75V output by using the procedure described in steps (a) through (e) above. Load the COMMON RETURN and (—) terminals and monitor the output voltage across the RETURN SENSE and (—SEN) terminals. Do not readjust the output voltage; the voltage of the negative supply should be within 1% +20mV of the positive supply's voltage.

5-13 Input Overvoltage Protection Checks (Models 61005E and 61315E Only)

5-14 Check the input overvoltage protection circuit in the dc-input models as follows:

a. Connect a dc voltmeter across the 5V output of the 61000-Series supply under test. (Leave the supply's output unloaded.)

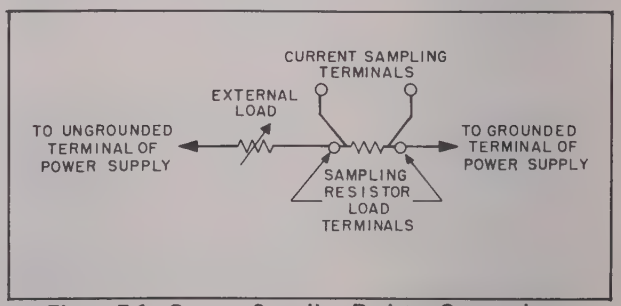

CURRENT SAMPLING TERMINALS
EXTERNAL LOAD
TO UNGROUNDED TERMINAL OF POWER SUPPLY
TO GROUNDED TERMINAL OF POWER SUPPLY
SAMPLING RESISTOR LOAD TERMINALS

Figure 5-1. Current Sampling Resistor Connections

b. Connect another dc voltmeter across the output of a variable dc supply with a 6A load capacity and an output adjustment range of 40Vdc to 70Vdc.

c. Set the variable dc supply's output to about 42 volts, turn this supply off, and connect its output to the input of the supply under test. (Observe correct polarity.)

d. Turn on the variable supply and increase its output voltage gradually while monitoring the voltage at the 5V output of the supply under test. The voltage at the supply's 5V output should fall to zero when its dc input voltage reaches about 63 or 64 volts.

NOTE

If the supply's input voltage reaches 66 volts before its 5V output falls to zero, do not increase the input voltage any further. Instead troubleshoot the malfunction of the input overvoltage comparator on the A1 board. (See Table 5-2.)

e. Now decrease the dc input voltage to the supply under test. The voltage at the supply's 5V output should return to normal before its input voltage reaches 59 volts.

5-15 Current Limit Checks

5-16 To check the operation of the current limit circuit(s), follow the procedure given in steps (f) and (g) of paragraph 3-2.

5-17 Output Overvoltage Protection Checks

5-18 To check the operation of the supply's output overvoltage crowbar circuit(s), follow the procedure given in steps (h), (i), and (j) of paragraph 3-2.

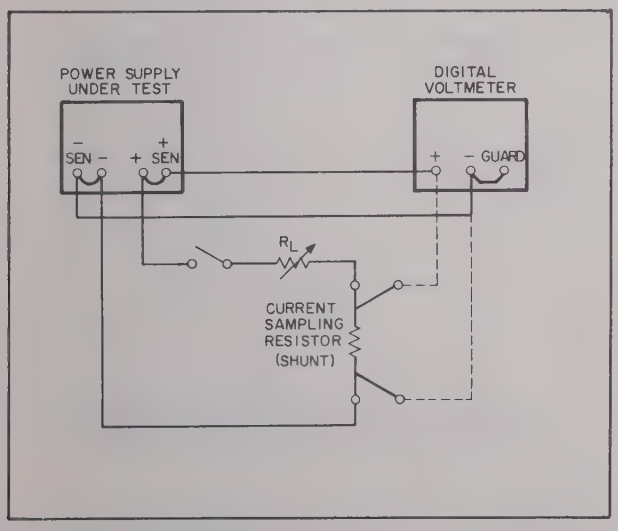


Figure 5-2. Rated Output, Test Setup

5-19 Load Effect (Load Regulation)

Definition: The change ΔE_{OUT} in the static value of dc output voltage resulting from a change in load resistance from open circuit to a value which yields maximum rated output current (or vice-versa).

5-20 To test the load effect:

a. Connect a full load resistance and a digital voltmeter across the (+) and (—) terminals of the 5V output, as shown in Figure 5-2.

b. Turn on the supply and record the voltage across the 5V output's sensing terminals.

c. Disconnect the load resistor and recheck the DVM indication. It should be within 0.04% +3mV of the reading in step (b).

d. Repeat steps (a) through (c) for each of the remaining supply outputs.

5-21 Source Effect (Line Regulation)

Definition: The change ΔE_{OUT}, in the static value of dc output voltage resulting from a change in input voltage over the specified range from low line to high line or from high line to low line.

5-22 To test the source effect:

a. (DC-input models). Connect the input of the supply under test to a source of dc voltage that can be adjusted from 42 to 56 volts.

(AC-input models). Connect a variable autotransform between the input power source and the power supply's ac input.

b. Connect a full load resistance and a digital voltmeter across the 5V output of the supply.

c. Adjust the power supply's input voltage to the low end of its operating range (42Vdc or 87Vac).

d. Turn on the power and record the DVM indication.

e. Adjust the power supply's input voltage to the high end of its operating range (56Vdc or 127Vac), and recheck the DVM indication. It should be within 0.1% of the reading in step (d). For dc input models and within 0.01% +1mV for ac input models.

f. Repeat steps (b) through (e) for each of the remaining supply outputs.

5-23 PARD (Ripple and Noise)

Definition: The residual ac voltage that is superimposed on the dc output of a regulated power supply. Ripple and noise may be specified and measured in terms of its rms or peak-to-peak value.

5-24 Measurement Techniques. Figure 5-3A shows an incorrect method of measuring p-p ripple. Note that a continuous ground loop exists from the third wire of the input power cord of the supply to the third wire of the input power cord of the oscilloscope via the grounded power supply case, the wire between the negative output

terminal of the power supply and the vertical input of the scope, and the grounded scope case. Any ground current circulating in this loop as a result of the difference in potential E_G between the two ground points causes an IR drop which is in series with the scope input. This IR drop, normally having a 60Hz line frequency fundamental, plus any pickup on the unshielded leads interconnecting the power supply and scope, appears on the face of the CRT. The magnitude of this resulting signal can easily be much greater than the true ripple developed between the plus and minus output terminals of the power supply and can completely invalidate the measurement.

5-25 Figure 5-3B shows a correct method of measuring the output ripple of a constant voltage power supply using a single-ended scope. The ground loop path is broken by floating the power supply output. To ensure that no potential difference exists between the supply and the oscilloscope, it is recommended that they both be plugged into the same ac power bus. If the same bus cannot be used, both ac grounds must be at earth ground potential.

5-26 To verify that the oscilloscope is not displaying ripple that is induced in the leads or picked up from the grounds, the (+) scope lead should be shorted to the (—) scope lead at the power supply terminals. The ripple value obtained when the leads are shorted should be subtracted from the actual ripple measurement.

5-27 Measurement Procedure. To measure the ripple and noise on each supply output, follow the steps below. If a high frequency noise measurement is desired, an oscilloscope with sufficient bandwidth (20MHz) must be used. Ripple and noise measurements can be made at any input ac line voltage combined with any dc output voltage and load current within rating.

a. Connect an oscilloscope or rms voltmeter across an output of the supply as shown in Figure 5-3B.

b. Energize the supply and observe the oscilloscope or meter indication. The ripple and noise should not be greater than 5mV rms or 40mV peak-to-peak.

c. Repeat for the remaining supply outputs.

5-28 Load Transient Recovery Time

Definition: The time it takes for the output voltage to recover to within 1% of the nominal output following a step change in output current.

5-29 ±11.4 to ±15.75-Volt Outputs. To test the load transient recovery time, a repetitive load switch with a fast switching time is required for loading and unloading the supply. Figure 5-4 shows one way of constructing one using a relay with mercury-wetted contacts. When this load switch is connected to a 60Hz ac input, the mercury relay opens and closes 60 times per second. The 25kΩ control adjusts the duty cycle of the load current switching to reduce jitter in the oscilloscope display. This load switch can also be used with a 50Hz ac input.

5-30 To check the load transient recovery time of each of the ±11.4 to ±15.75V outputs of the Model 61315E or 63315E, proceed as follows:

a. Connect test setup as shown in Figure 5-4. Each load resistor (R1 and R2) is twice the normal full load resistance.

b. Turn on the supply and close the line switch on the repetitive load switch.

c. Adjust the oscilloscope to display the loading and the unloading transients produced by the operation of the load switch. Recovery to within 1% of the nominal output voltage should occur within 25 microseconds as shown in Figure 5-5.

5-31 5-Volt Output. The mercury-wetted relays recommended for use in the repetitive load switch described in Figure 5-4 have a maximum current limitation of 5 amps. For this reason, some other type of repetitive load switch with a higher current capacity is required for testing the

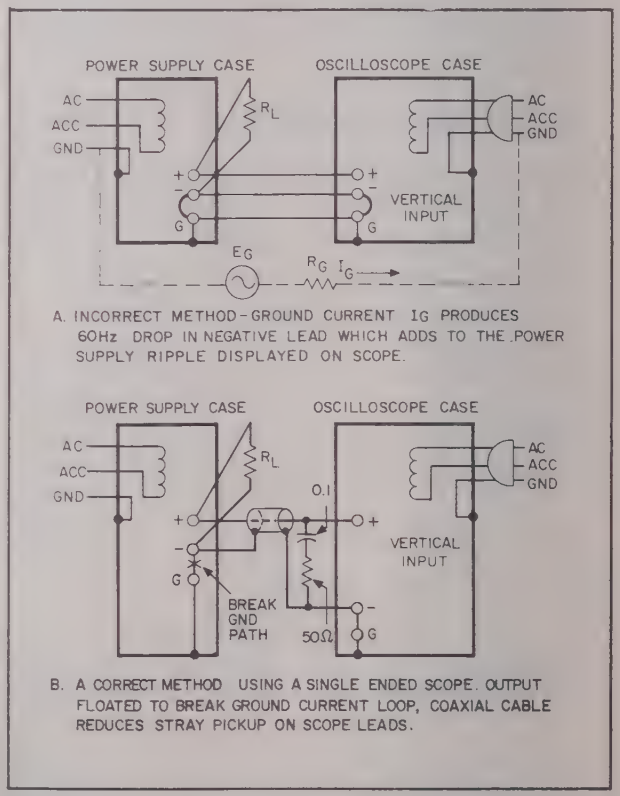

POWER SUPPLY CASE
OSCILLOSCOPE CASE
AC
ACC
GND
R_L
VERTICAL INPUT
E_G
R_G I_G
A. INCORRECT METHOD - GROUND CURRENT IG PRODUCES 60Hz DROP IN NEGATIVE LEAD WHICH ADDS TO THE POWER SUPPLY RIPPLE DISPLAYED ON SCOPE.
0.1
BREAK GND PATH
50Ω
B. A CORRECT METHOD USING A SINGLE ENDED SCOPE. OUTPUT FLOATED TO BREAK GROUND CURRENT LOOP, COAXIAL CABLE REDUCES STRAY PICKUP ON SCOPE LEADS.

Figure 5-3. Ripple and Noise, Test Setup

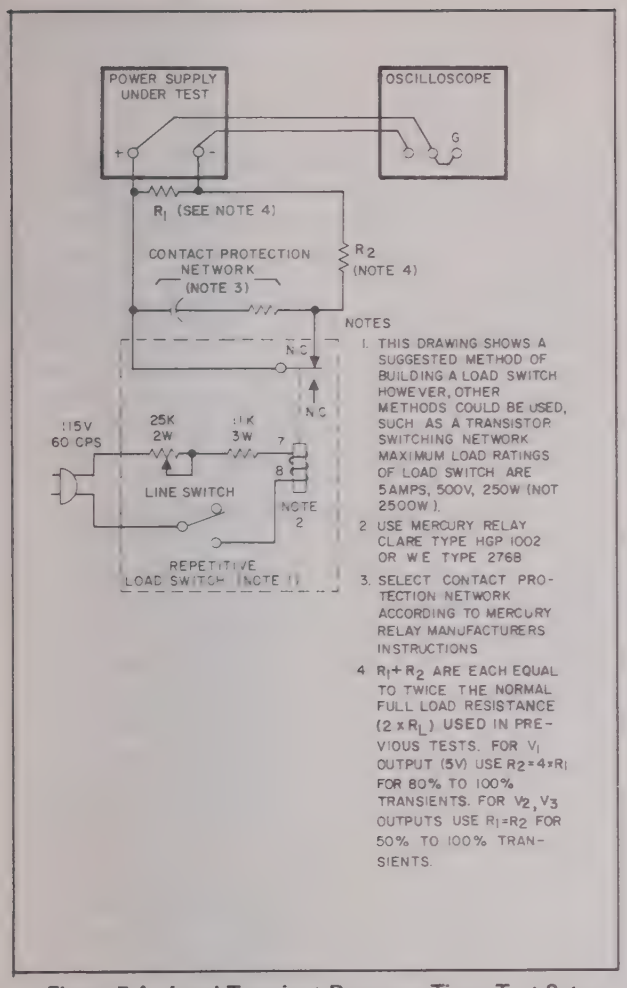

POWER SUPPLY UNDER TEST
OSCILLOSCOPE
+
-
G
R1 (SEE NOTE 4)
CONTACT PROTECTION NETWORK (NOTE 3)
R2 (NOTE 4)
NOTES
1. THIS DRAWING SHOWS A SUGGESTED METHOD OF BUILDING A LOAD SWITCH HOWEVER, OTHER METHODS COULD BE USED, SUCH AS A TRANSISTOR SWITCHING NETWORK. MAXIMUM LOAD RATINGS OF LOAD SWITCH ARE 5AMPS, 500V, 250W (NOT 2500W).
2. USE MERCURY RELAY CLARE TYPE HGP 1002 OR W E TYPE 276B
3. SELECT CONTACT PROTECTION NETWORK ACCORDING TO MERCURY RELAY MANUFACTURERS INSTRUCTIONS.
4. R1+R2 ARE EACH EQUAL TO TWICE THE NORMAL FULL LOAD RESISTANCE (2 x RL) USED IN PREVIOUS TESTS. FOR V1 OUTPUT (5V) USE R2=4xR1 FOR 80% TO 100% TRANSIENTS. FOR V2, V3 OUTPUTS USE R1=R2 FOR 50% TO 100% TRANSIENTS.
N.C.
N.C.
115V 60 CPS
25K 2W
1K 3W
7
8
LINE SWITCH
NOTE 2
REPETITIVE LOAD SWITCH (NOTE 1)

Figure 5-4. Load Transient Recovery Time, Test Setup

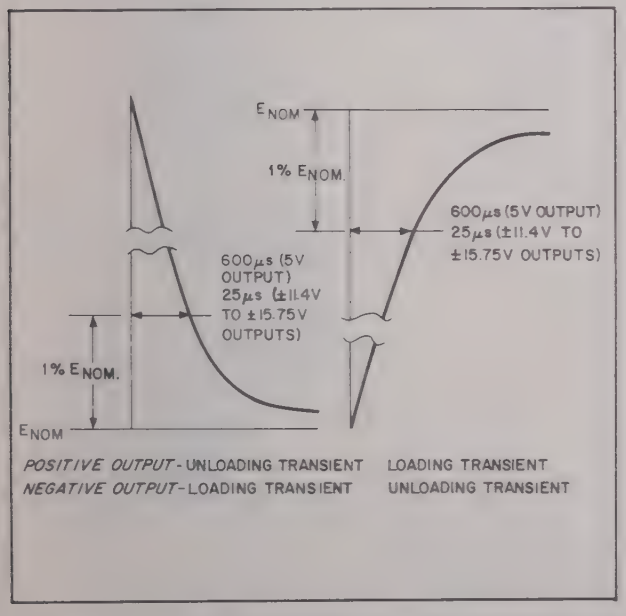


Figure 5-5. Load Transient Recovery Time Waveforms

load transient recovery time of the 5V output if a full load change is desired. The use of a solid state electrical load with pulse modulation capabilites such as the Transistor Devices Dynaload DLP 50-60-1000 is one way to avoid the rise time and switching noise limitations of mechanical switches at currents above 5 amps.

5-32 To check the load transient recovery time of the 5V output, proceed as follows:

a. Connect test setup as shown in Figure 5-4, but in place of the R1, R2 and the contact protection network shown, substitute a solid state repetitive load switch with a current capacity of at least the supply's rated output and a rise time of less than 100 microseconds. Adjust the solid state load for an output current change from 80% to 100% of the full load.

b. Turn on the supply and the load switch.

c. Adjust the oscilloscope to display the loading and the unloading transients produced by the operation of the load switch. Recovery to within 1% of the nominal output voltage should occur within 600μs as shown in Figure 5.5.

5-33 TROUBLESHOOTING

5-34 Before attempting to troubleshoot this instrument, ensure that the fault is in the instrument itself and not in an associated piece of equipment. You can determine this without removing the covers from the instrument by using the appropriate portions of the performance test of paragraph 5-6.

5-35 A good understanding of the principles of operation is a helpful aid in troubleshooting, and the reader is advised to review Section IV of the manual before beginning detailed troubleshooting. Once the principles of operation are understood, proceed to the initial troubleshooting procedures in paragraph 5-36.

5-36 Initial Troubleshooting Procedures

WARNING

In the ac-input models all circuits on the A1 board as well as the primary windings of transformer T2 on the A2 board are connected directly to the input ac line. Exercise extreme caution when working on energized circuits. Also, energize the supply through an isolation transformer with a power rating of at least 900VA to avoid shorting ac line energized circuits to ground through the test instrument's input leads.

CAUTION

Before applying power to the supply, make certain that jumpers E1 through E5 on TB1 are connected appropriately for the ac line voltage to be used (see paragraph 2-16).

All loads should be disconnected while troubleshooting. If checks must be made that require loading the supply while the circuit boards are detached from the main heatsink, restrict the time the output is load to 60 seconds to avoid overheating.

5-37 If a malfunction occurs that causes an output voltage to be high, low, or zero, proceed to the circuit board isolation procedure of Figure 5-6. This procedure identifies the board on which troubleshooting must begin. The A1 board must be operating properly before troubleshooting of the A2 board can proceed, and both the A1 and A2 boards must be operating properly before troubleshooting the A3 board. Follow all steps in the order in which they are given.

5-38 If the unit's output voltages are normal but difficulties exist with its ripple, noise, or regulation, proceed to Table 5-2.

5-39 REPAIR AND REPLACEMENT

5-40 Disassembly

5-41 Follow the steps below to disassemble the unit for troubleshooting and repair.

a. Before removing the cover, remove the plastic barrier block cover and disconnect all input and output connections.

b. Remove six screws at the bottom edge of the cover and two at the top. The cover then can be slid off the supply.

c. Detach the finned heatsink by removing its four screws.

d. Remove the two spacer rods from the top of the circuit boards.

e. Remove one screw from the bottom of the unit that attaches the A3 board to the chassis in the Model 61315E or 63315E.

f. Now, remove and save the four or six flat-head screws (100°) that were exposed by the removal of the heatsink and the three screws along the bottom edge of the A1 board (and the two screws at the corners of the A2 or A3 board will permit all boards to be detached from the chassis as a single assembly. In the Model 63005E or 63315E, three A4L1 leads and one ground wire still connect the A1 board to the chassis.

g. The A1 board can be detached from the A2/A3 assembly by pulling straight apart to unplug the pins at the top of A2T2 from A1J1.

h. To separate the A2 and A3 boards, remove the two screws at opposite corners.

5-42 Reassembly

5-43 To reassemble the unit after repairs have been completed, reverse the above disassembly steps. Before reassembling the A1 and A2 boards to the inside of the rear chassis, it is important to clean the mating surfaces and both sides of the sheet of insulation material that goes between them and apply a coating of thermal grease (HP Part No. 6040-0519) or (American Oil Compound 100) to these surfaces. Also apply thermal grease to the outside of the rear chassis to ensure proper heat transfer to the rear heat sink. Be sure to use 100° screws to reassemble the A1, A2 boards to the inside of the rear chassis.

5-44 Replacing Power Semiconductors

5-45 Replace heatsink mounted power transistors and diodes by removing their mounting screws and unsoldering their pins. Use mica insulators under A2Q1, A2U2, A3Q1, and A3Q4, but do not use one under A1Q4 or Q5 in 61000-Series supplies or under A1Q5 in 63000-Series supplies. (The mica insulator for A2Q1 is supplied with the replacement device.) When replacing power semiconductors, coat the heat transfer surfaces with silicone grease.

NOTE

When replacing any wirewound power resistors of 3W rating or greater, allow a 1/4-inch clearance between the resistor and the circuit board.

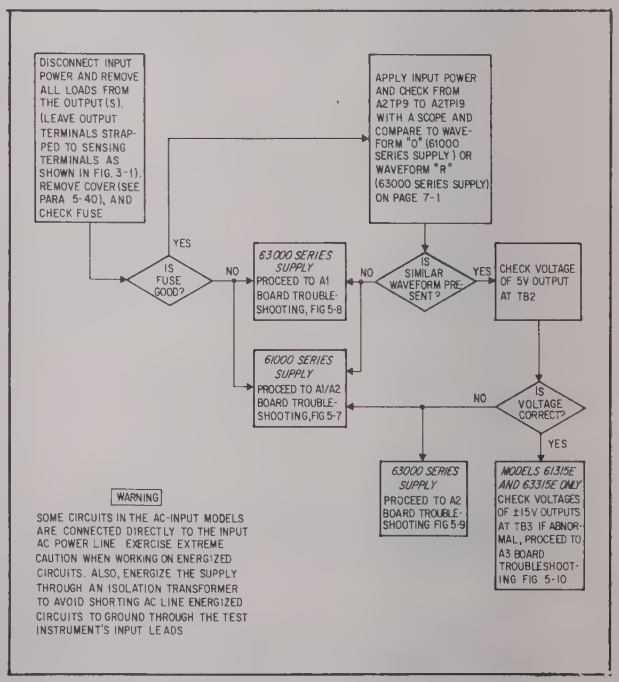

DISCONNECT INPUT POWER AND REMOVE ALL LOADS FROM THE OUTPUT(S). (LEAVE OUTPUT TERMINALS STRAPPED TO SENSING TERMINALS AS SHOWN IN FIG. 3-1). REMOVE COVER (SEE PARA 5-40), AND CHECK FUSE
APPLY INPUT POWER AND CHECK FROM A2TP9 TO A2TP19 WITH A SCOPE AND COMPARE TO WAVEFORM "O" (61000 SERIES SUPPLY) OR WAVEFORM "R" (63000 SERIES SUPPLY) ON PAGE 7-1
YES
IS FUSE GOOD?
NO
63000 SERIES SUPPLY
PROCEED TO A1 BOARD TROUBLESHOOTING, FIG 5-8
NO
IS SIMILAR WAVEFORM PRESENT?
YES
CHECK VOLTAGE OF 5V OUTPUT AT TB2
61000 SERIES SUPPLY
PROCEED TO A1/A2 BOARD TROUBLESHOOTING, FIG 5-7
NO
IS VOLTAGE CORRECT?
YES
63000 SERIES SUPPLY
PROCEED TO A2 BOARD TROUBLESHOOTING FIG 5-9
MODELS 61315E AND 63315E ONLY
CHECK VOLTAGES OF ±15V OUTPUTS AT TB3 IF ABNORMAL, PROCEED TO A3 BOARD TROUBLESHOOTING FIG 5-10
WARNING
SOME CIRCUITS IN THE AC-INPUT MODELS ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS. ALSO, ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS

Figure 5-6. Circuit Board Isolation Procedure

5-46 ADJUSTMENTS

NOTE

Before adjusting an output current limit, the voltage of that output must be set to the desired value.

5-47 To adjust the setting of one of the output current limit circuits, proceed as follows:

a. Before energizing the supply, connect across the output an oscilloscope and a load resistor equal in value to the desired output voltage divided by the desired current limit. (For example, to set the current limit of the 5V output to 20 amps when the output is set for 5.20 volts, a 260-milliohm 100-watt load resistor is required.)

b. Turn the current limit adjusting pot for the output being adjusted fully clockwise (CW) to its maximum setting.

c. Energize the supply and monitor the output ripple while turning the current limit adjusting pot gradually counterclockwise (CCW) until the ripple begins to increase substantially. Set the pot to the point where the increase in ripple begins.

Table 5-2. Miscellaneous Troubleshooting

Symptom	Probable Cause
Excessive 120Hz ripple (ac-input models).	Check voltage and ripple at preregulator output (A2TP1 to TP2). Voltage should be +106 ±5Vdc. Ripple should not exceed 14V p-p with the supply fully loaded. Check A1C2-C7.
Excessive 20kHz ripple or noise spikes.	Check all board mounting screws tightened securely and the following components. 5V Output: Check A2C3, C5, C12, C16-19, L1, L3. ±15V Outputs: Check A3C1, C2, C8-C11, C16-18, C20, C21, L1, L2, L5, L6.
Erratic output at some value of load current.	Check A2CR3, C4, R7, R8, R11.
Poor regulation.	a. Check remote sensing connections. b. Check the settings of current limit controls A2R34, A3R9, and A3R23. c. (Ac-input models). Check change in preregulator dc output (A1TP1 to TPT2) as the supply is load. Troubleshoot preregulator if voltage change exceeds 2Vdc at nominal line. d. Check bias voltages: A2TP1 to TP2 (+12 to +16Vdc), A2TP1 to TP3 (+8 to +10Vdc). A2TP1 to V4 Pin 12 (+13 to +17Vdc). e. Check reference voltages: A2TP13 to TP20 (+6.8 to +7.5Vdc), and COMMON RETURN on TB3 to A3TP20 (+6.8 to +7.5Vdc). f. Check regulator IC's (A2U4, A3U1, A3U2) and pulse width modulator (A2U1).
Input overvoltage protection does not operate (dc-input models).	Check Q1, CR2, U1, VR1, R2, R3.

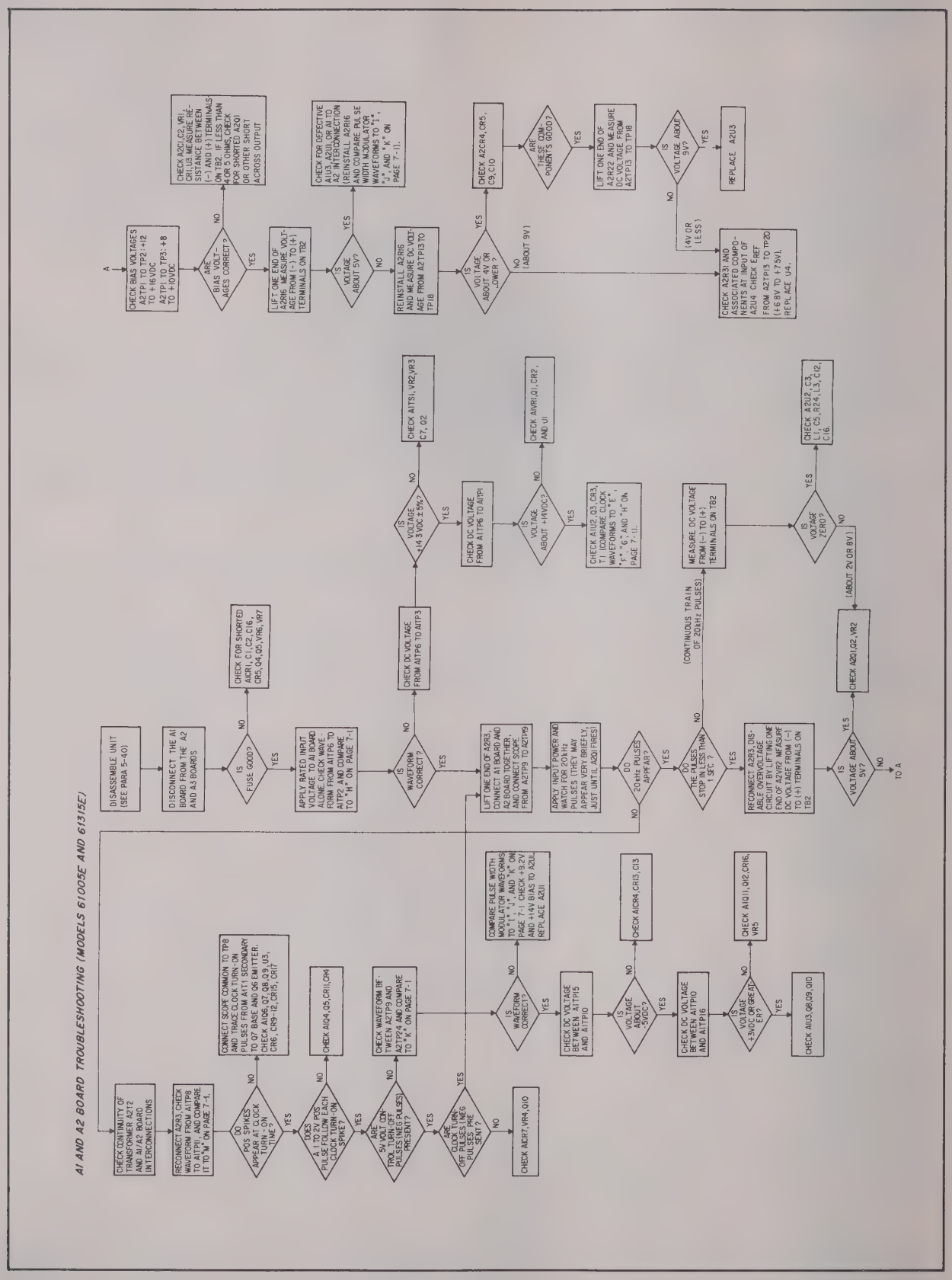

A1 AND A2 BOARD TROUBLESHOOTING (MODELS 61005E AND 61315E)
DISASSEMBLE UNIT (SEE PARA 5-40)
DISCONNECT THE A1 BOARD FROM THE A2 AND A3 BOARDS
IS FUSE GOOD?
CHECK FOR SHORTED A6CR1, C1, C2, C16, CR5, Q4, Q5, VR6, VR7
APPLY RATED INPUT VOLTAGE TO A1 BOARD ASSEMBLY. CHECK WAVE FORM FROM A1TP6 TO A1TP2 AND COMPARE TO "H" ON PAGE 7-1.
IS WAVEFORM CORRECT?
CHECK DC VOLTAGE FROM A1TP6 TO A1TP3
IS VOLTAGE +14.3 VDC ± 5%?
CHECK A1TS1, VR2, VR3 C7, Q2
CHECK DC VOLTAGE FROM A1TP6 TO A1TP1
IS VOLTAGE ABOUT +14 VDC?
CHECK A1VR1, Q1, CR2, AND U1
CHECK A1U2, Q3, CR3, T1 (COMPARE CLOCK WAVEFORMS TO "E", "F", "G", AND "H" ON PAGE 7-1).
LIFT ONE END OF A2R3, CONNECT A1 BOARD AND A2 BOARD TOGETHER, AND CONNECT SCOPE FROM A2TP3 TO A2TP3
APPLY INPUT POWER AND WATCH FOR 20 kHz PULSES (THEY MAY APPEAR VERY BRIEFLY, JUST UNTIL A2Q1 FIRES)
DO 20 kHz PULSES APPEAR?
MEASURE DC VOLTAGE FROM (−) TO (+) TERMINALS ON TB2
(CONTINUOUS TRAIN OF 20 kHz PULSES)
DO PULSES STOP IN LESS THAN 1 SEC ?
IS VOLTAGE ZERO?
CHECK A2U2, C3, L1, C5, R24, L3, C12, C16.
(ABOUT 2V OR 8V)
CHECK A2Q1, Q2, VR2
RECONNECT A2R3, DISABLE OVERVOLTAGE CIRCUIT BY LIFTING ONE END OF A2VR2. MEASURE DC VOLTAGE FROM (−) TO (+) TERMINALS ON TB2
IS VOLTAGE ABOUT 5V?
TO A
CHECK A1CR7, VR4, Q10
CHECK A1Q4, Q5, CR11, CR14
CHECK A1Q3, Q8, Q9, U3, CR6, CR9-12, CR15, CR17
CONNECT SCOPE COMMON TO TP8 AND TRACE CLOCK TURN-ON PULSES FROM A1T1 SECONDARY TO Q7 BASE AND Q6 EMITTER. CHECK A1Q6, Q7, Q8, Q9, U3, CR6, CR9-12, CR15, CR17
CHECK WAVEFORM BETWEEN A2TP9 AND A2TP24 AND COMPARE TO "K" ON PAGE 7-1
ARE 5V VOLT CONTROL TURN-OFF PULSES (NEG PULSES) PRESENT?
ARE CLOCK TURN-OFF PULSES (NEG PULSES) ARE SENT?
COMPARE PULSE WIDTH MODULATOR WAVEFORMS TO "I", "J", AND "K" ON PAGE 7-1. CHECK +9.2V AND +14V BIAS TO A2U1. REPLACE A2U1
CHECK DC VOLTAGE BETWEEN A1TP15 AND A1TP10
CHECK A1CR4, CR13, C13
CHECK DC VOLTAGE BETWEEN A1TP10 AND A1TP16
CHECK A1Q11, Q12, CR16, VR5
CHECK A1U3, Q6, Q9, Q10
A
CHECK BIAS VOLTAGES A2TP1 TO TP2: +12 TO +16 VDC A2TP1 TO TP3: +8 TO +10 VDC
ARE BIAS VOLTAGES CORRECT?
CHECK A2D1, C2, VR1, CR1, L13. MEASURE RESISTANCE BETWEEN (−) AND (+) TERMINALS ON TB2. IF LESS THAN 5 OHMS, CHECK FOR SHORTED CR1 OR OTHER SHORT ACROSS OUTPUT
LIFT ONE END OF A2R6 MEASURE VOLTAGE FROM (−) TO (+) TERMINALS ON TB2
IS VOLTAGE ABOUT 5V?
CHECK FOR DEFECTIVE A1U3, A2U1, OR A1 TO A2 INTERCONNECTION (REINSTALL A2R6 AND COMPARE PULSE WIDTH MODULATOR WAVEFORMS TO "I", "J", AND "K" ON PAGE 7-1).
REINSTALL A2R6 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18
IS VOLTAGE ABOUT 4V OR LOWER ?
CHECK A2CR4, CR5, C9, C10
ARE THESE COMPONENTS GOOD?
LIFT ONE END OF A2VR2 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18
IS VOLTAGE ABOUT 5V?
REPLACE A2U3
CHECK A2R31 AND ASSOCIATED COMPONENTS AT INPUT OF A2U4. CHECK EREF FROM A2TP13 TO TP20 (+6.8V TO +7.5V). REPLACE U4.
YES
NO
(4V OR LESS)
(ABOUT 9V)

Figure 5-7. A1/A2 Board Troubleshooting Procedure, 61000-Series Supplies

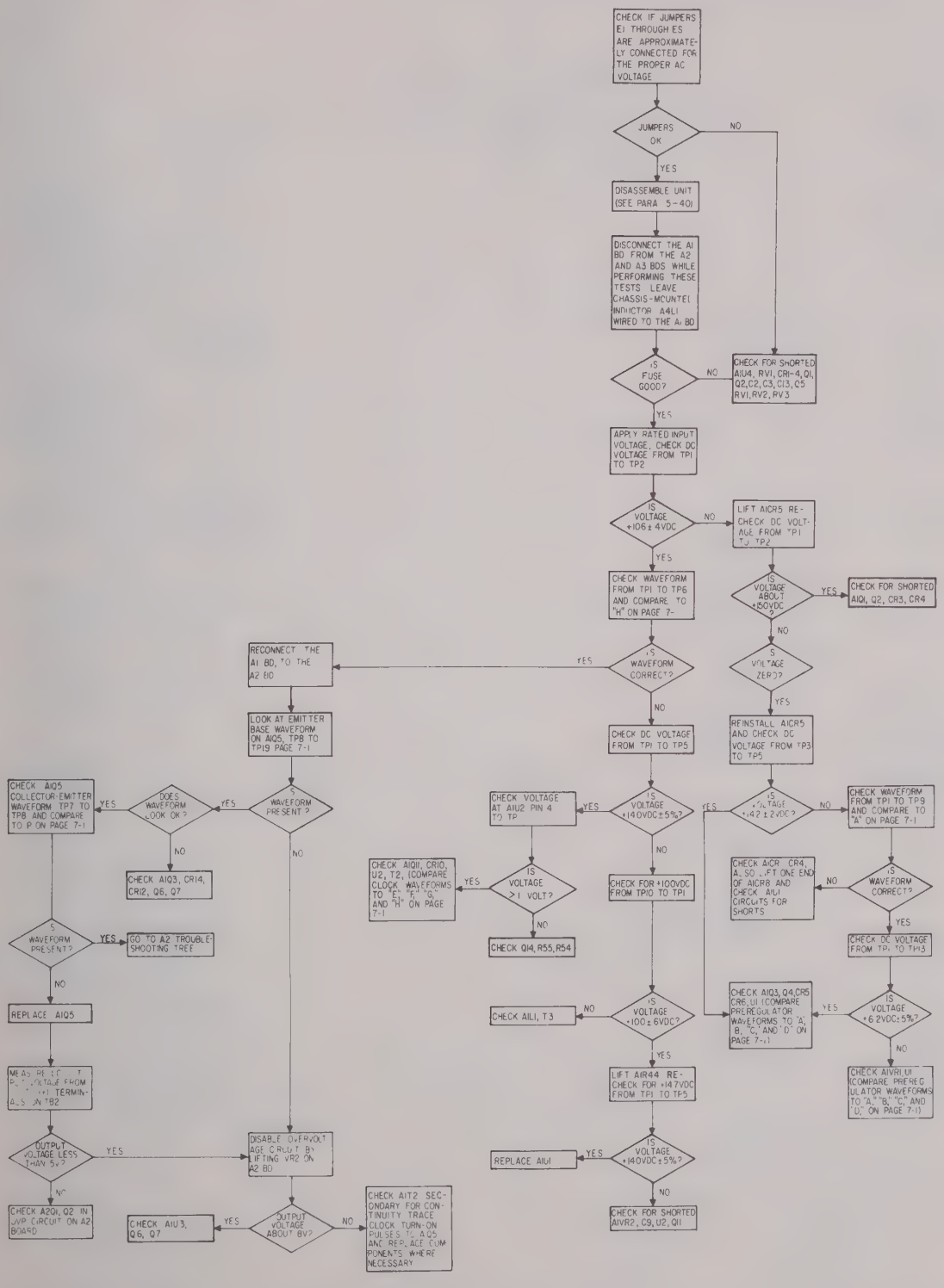

CHECK IF JUMPERS E1 THROUGH E5 ARE APPROXIMATELY CONNECTED FOR THE PROPER AC VOLTAGE
JUMPERS OK
NO
YES
DISASSEMBLE UNIT (SEE PARA 5-40)
DISCONNECT THE A1 BD FROM THE A2 AND A3 BDS WHILE PERFORMING THESE TESTS. LEAVE CHASSIS-MOUNTED INDICTOR A4L1 WIRED TO THE A1 BD
IS FUSE GOOD?
NO
CHECK FOR SHORTED A1U4, RV1, CR1-4, Q1, Q2, C2, C3, C13, C5, RV1, RV2, RV3
YES
APPLY RATED INPUT VOLTAGE, CHECK DC VOLTAGE FROM TP1 TO TP2
IS VOLTAGE +106 ± 4VDC
NO
LIFT A1CR5 RE-CHECK DC VOLTAGE FROM "TP1 TO TP2
YES
CHECK WAVEFORM FROM TP1 TO TP6 AND COMPARE TO "H" ON PAGE 7-
IS VOLTAGE ABOUT +50VDC?
YES
CHECK FOR SHORTED A1Q1, Q2, CR3, CR4
NO
IS WAVEFORM CORRECT?
YES
IS VOLTAGE ZERO?
YES
NO
RECONNECT THE A1 BD, TO THE A2 BD
LOOK AT EMITTER BASE WAVEFORM ON A1Q5, TPB TO TP19 PAGE 7-1
CHECK DC VOLTAGE FROM TP1 TO TP5
REINSTALL A1CR5 AND CHECK DC VOLTAGE FROM TP3 TO TP5
CHECK A1Q5 COLLECTOR-EMITTER WAVEFORM TP7 TO TP8 AND COMPARE TO P ON PAGE 7-1
YES
DOES WAVEFORM LOOK OK?
YES
IS WAVEFORM PRESENT?
NO
CHECK A1Q3, CR14, CR12, Q6, Q7
CHECK VOLTAGE AT A1U2 PIN 4 TO TP
YES
IS VOLTAGE +14 0VDC ± 5%?
YES
IS VOLTAGE +.42 ± 2VDC?
NO
CHECK WAVEFORM FROM TP1 TO TP9 AND COMPARE TO "A" ON PAGE 7-1
CHECK A1Q11, CR10, U2, T2, (COMPARE CLOCK WAVEFORMS TO "E", "G" AND "H" ON PAGE 7-1
YES
IS VOLTAGE > 1 VOLT?
NO
CHECK Q14, R55, R54
NO
CHECK FOR +100VDC FROM TP10 TO TP1
CHECK A1CR4, CR4, ALSO ...FT ONE END OF A1CR8 AND CHECK A1U1 CIRCUITS FOR SHORTS
NO
IS WAVEFORM CORRECT?
YES
CHECK DC VOLTAGE FROM TP1 TO TP13
IS WAVEFORM PRESENT?
YES
GO TO A2 TROUBLE-SHOOTING TREE
NO
REPLACE A1Q5
CHECK A1L1, T3
NO
IS VOLTAGE +100 ± 6VDC?
YES
CHECK A1Q3, Q4, CR5 CR6, U1 (COMPARE PREREGULATOR WAVEFORMS TO 'A', 'B', 'C,' AND 'D' ON PAGE 7-1)
YES
IS VOLTAGE +6 2VDC ± 5%?
NO
CHECK A1VR1, U1 (COMPARE PREREGULATOR WAVEFORMS TO "A," "B," "C," AND "D" ON PAGE 7-1)
LIFT A1R44 RE-CHECK FOR +14 7VDC FROM TP1 TO TP5
OUTPUT VOLTAGE LESS THAN 5V?
YES
DISABLE OVERVOLTAGE CIRCUIT BY LIFTING VR2 ON A2 BD
REPLACE A1U1
YES
IS VOLTAGE +14 0VDC ± 5%?
NO
CHECK FOR SHORTED A1VR2, C9, U2, Q11
NO
CHECK A2Q1, Q2 IN OVP CIRCUIT ON A2 BOARD
CHECK A1U3, Q6, Q7
YES
OUTPUT VOLTAGE ABOUT 8V?
NO
CHECK A1T2 SECONDARY FOR CONTINUITY. TRACE CLOCK TURN-ON PULSES TO A2Q5 AND REPLACE COMPONENTS WHERE NECESSARY

Figure 5-8. A1 Board Troubleshooting Procedure, 63000-Series Supplies

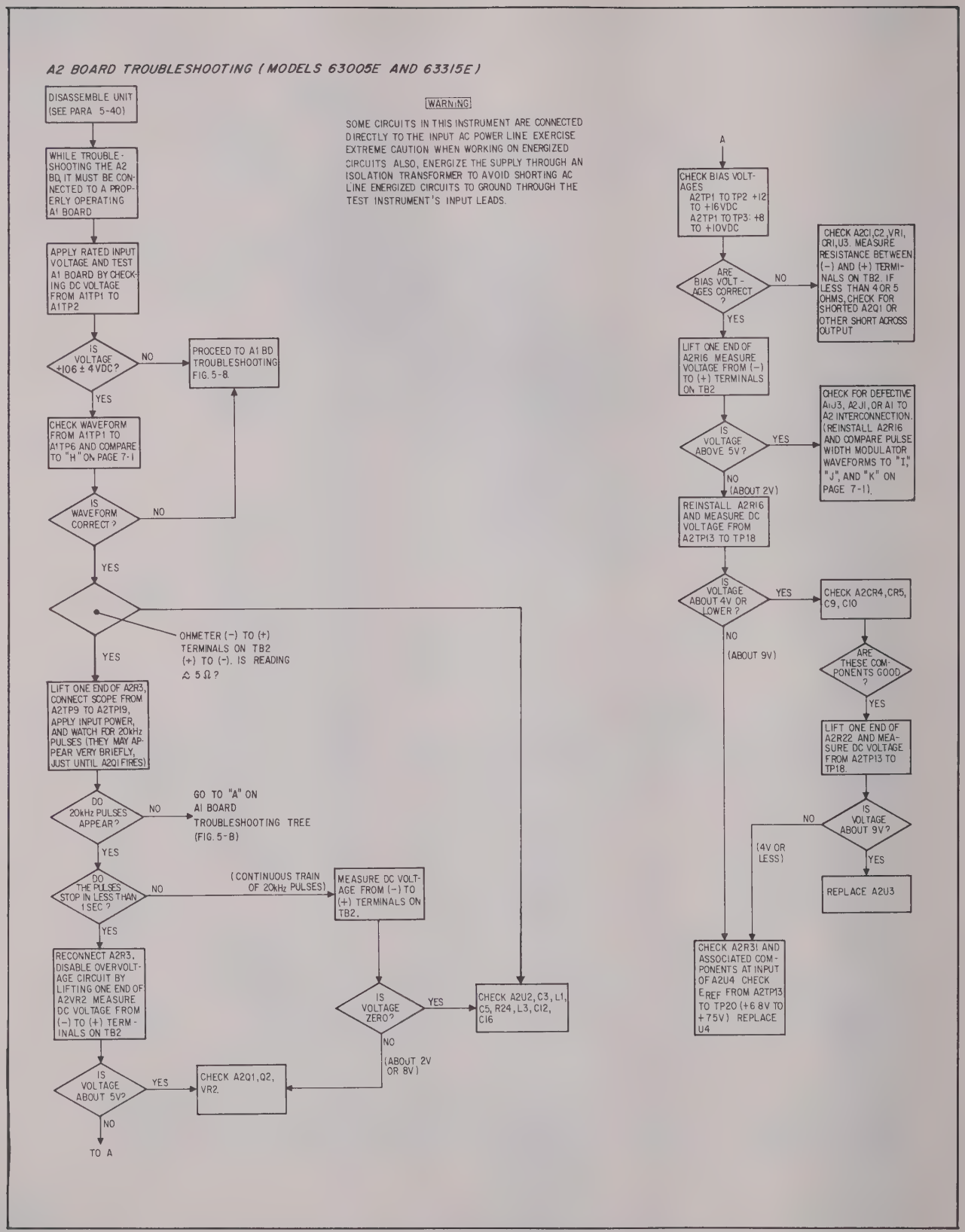

A2 BOARD TROUBLESHOOTING (MODELS 63005E AND 63315E)
DISASSEMBLE UNIT (SEE PARA 5-40)
WHILE TROUBLE-SHOOTING THE A2 BD, IT MUST BE CONNECTED TO A PROPERLY OPERATING A1 BOARD
APPLY RATED INPUT VOLTAGE AND TEST A1 BOARD BY CHECKING DC VOLTAGE FROM A1TP1 TO A1TP2
IS VOLTAGE +106 ± 4 VDC?
NO
PROCEED TO A1 BD TROUBLESHOOTING FIG. 5-8.
YES
CHECK WAVEFORM FROM A1TP1 TO A1TP6 AND COMPARE TO "H" ON PAGE 7-1
IS WAVEFORM CORRECT?
NO
YES
OHMETER (−) TO (+) TERMINALS ON TB2 (+) TO (−). IS READING ≈ 5Ω?
YES
LIFT ONE END OF A2R3, CONNECT SCOPE FROM A2TP9 TO A2TP19, APPLY INPUT POWER, AND WATCH FOR 20kHz PULSES (THEY MAY APPEAR VERY BRIEFLY, JUST UNTIL A2Q1 FIRES)
DO 20kHz PULSES APPEAR?
NO
GO TO "A" ON A1 BOARD TROUBLESHOOTING TREE (FIG. 5-8)
YES
DO THE PULSES STOP IN LESS THAN 1 SEC?
NO
(CONTINUOUS TRAIN OF 20kHz PULSES)
MEASURE DC VOLTAGE FROM (−) TO (+) TERMINALS ON TB2.
YES
RECONNECT A2R3, DISABLE OVERVOLTAGE CIRCUIT BY LIFTING ONE END OF A2VR2. MEASURE DC VOLTAGE FROM (−) TO (+) TERMINALS ON TB2
IS VOLTAGE ZERO?
YES
CHECK A2U2, C3, L1, C5, R24, L3, C12, C16
NO
(ABOUT 2V OR 8V)
IS VOLTAGE ABOUT 5V?
YES
CHECK A2Q1, Q2, VR2.
NO
TO A
WARNING
SOME CIRCUITS IN THIS INSTRUMENT ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS. ALSO, ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS.
A
CHECK BIAS VOLTAGES A2TP1 TO TP2 +12 TO +16VDC A2TP1 TO TP3: +8 TO +10VDC
ARE BIAS VOLTAGES CORRECT?
NO
CHECK A2C1, C2, VR1, CR1, U3. MEASURE RESISTANCE BETWEEN (−) AND (+) TERMINALS ON TB2. IF LESS THAN 4 OR 5 OHMS, CHECK FOR SHORTED A2Q1 OR OTHER SHORT ACROSS OUTPUT
YES
LIFT ONE END OF A2R16. MEASURE VOLTAGE FROM (−) TO (+) TERMINALS ON TB2
IS VOLTAGE ABOVE 5V?
YES
CHECK FOR DEFECTIVE A1J3, A2J1, OR A1 TO A2 INTERCONNECTION. (REINSTALL A2R16 AND COMPARE PULSE WIDTH MODULATOR WAVEFORMS TO "I," "J," AND "K" ON PAGE 7-1).
NO
(ABOUT 2V)
REINSTALL A2R16 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18
IS VOLTAGE ABOUT 4V OR LOWER?
YES
CHECK A2CR4, CR5, C9, C10
NO
(ABOUT 9V)
ARE THESE COMPONENTS GOOD?
YES
LIFT ONE END OF A2R22 AND MEASURE DC VOLTAGE FROM A2TP13 TO TP18.
IS VOLTAGE ABOUT 9V?
NO
(4V OR LESS)
YES
REPLACE A2U3
CHECK A2R31 AND ASSOCIATED COMPONENTS AT INPUT OF A2U4. CHECK EREF FROM A2TP13 TO TP20 (+6.8V TO +7.5V). REPLACE U4

Figure 5-9. A2 Board Troubleshooting, 63000-Series Supplies

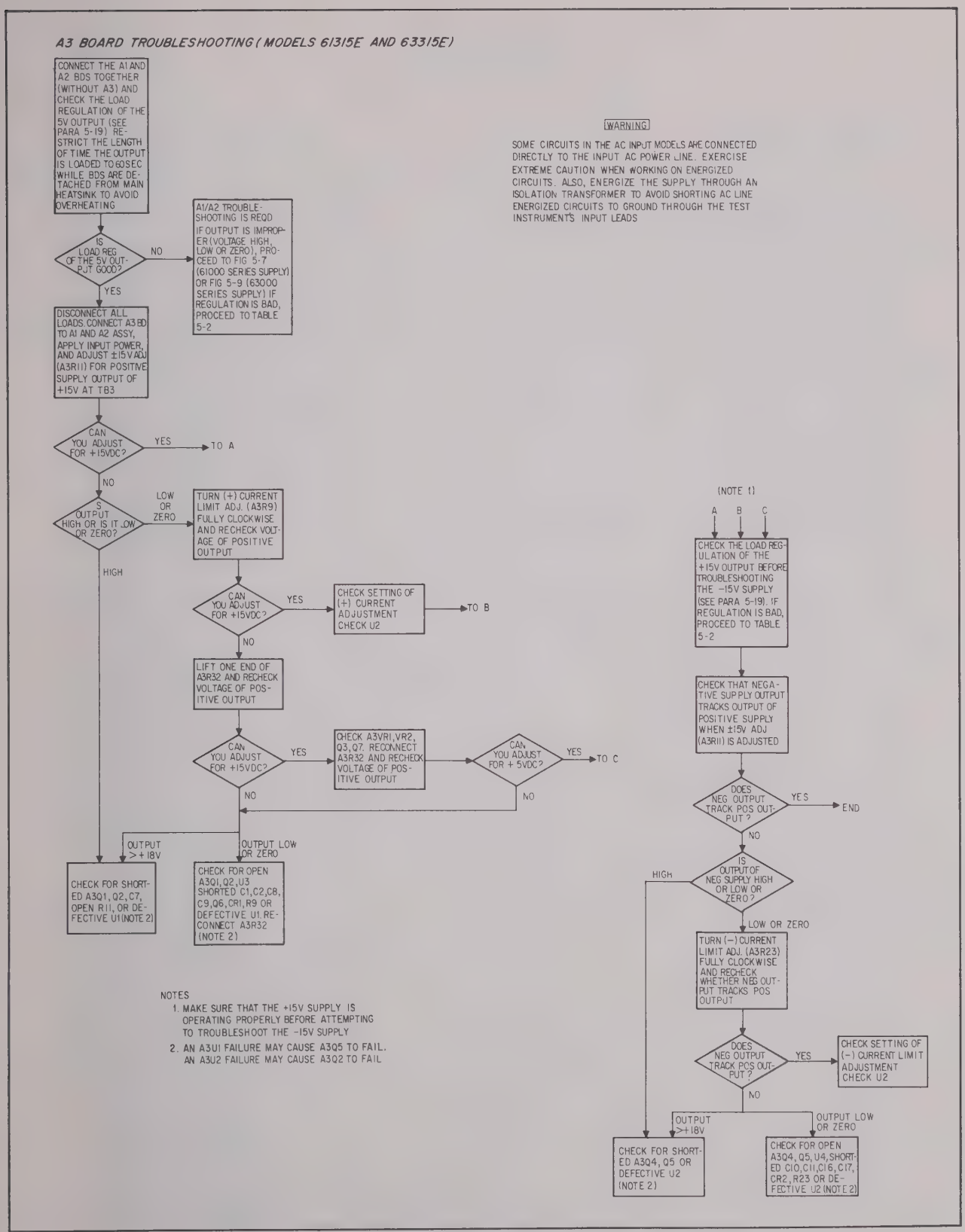

A3 BOARD TROUBLESHOOTING (MODELS 61315E AND 63315E)
CONNECT THE A1 AND A2 BDS TOGETHER (WITHOUT A3) AND CHECK THE LOAD REGULATION OF THE 5V OUTPUT (SEE PARA 5-19). RESTRICT THE LENGTH OF TIME THE OUTPUT IS LOADED TO 60 SEC WHILE BDS ARE DETACHED FROM MAIN HEATSINK TO AVOID OVERHEATING
IS LOAD REG OF THE 5V OUTPUT GOOD?
NO
YES
A1/A2 TROUBLESHOOTING IS REQD IF OUTPUT IS IMPROPER (VOLTAGE HIGH, LOW OR ZERO), PROCEED TO FIG 5-7 (61000 SERIES SUPPLY) OR FIG 5-9 (63000 SERIES SUPPLY) IF REGULATION IS BAD, PROCEED TO TABLE 5-2
DISCONNECT ALL LOADS. CONNECT A3 BD TO A1 AND A2 ASSY, APPLY INPUT POWER, AND ADJUST ±15V ADJ (A3R11) FOR POSITIVE SUPPLY OUTPUT OF +15V AT TB3
CAN YOU ADJUST FOR +15VDC?
YES
TO A
NO
IS OUTPUT HIGH OR IS IT LOW OR ZERO?
LOW OR ZERO
TURN (+) CURRENT LIMIT ADJ. (A3R9) FULLY CLOCKWISE AND RECHECK VOLTAGE OF POSITIVE OUTPUT
HIGH
CAN YOU ADJUST FOR +15VDC?
YES
CHECK SETTING OF (+) CURRENT ADJUSTMENT CHECK U2
TO B
NO
LIFT ONE END OF A3R32 AND RECHECK VOLTAGE OF POSITIVE OUTPUT
CAN YOU ADJUST FOR +15VDC?
YES
CHECK A3VR1, VR2, Q3, Q7. RECONNECT A3R32 AND RECHECK VOLTAGE OF POSITIVE OUTPUT
CAN YOU ADJUST FOR +5VDC?
YES
TO C
NO
NO
OUTPUT >+18V
OUTPUT LOW OR ZERO
CHECK FOR SHORTED A3Q1, Q2, C7, OPEN R11, OR DEFECTIVE U1 (NOTE 2)
CHECK FOR OPEN A3Q1, Q2, U3 SHORTED C1, C2, C8, C9, Q6, CR1, R9 OR DEFECTIVE U1. RECONNECT A3R32 (NOTE 2)
WARNING
SOME CIRCUITS IN THE AC INPUT MODELS ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS. ALSO, ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS
(NOTE 1)
A
B
C
CHECK THE LOAD REGULATION OF THE +15V OUTPUT BEFORE TROUBLESHOOTING THE -15V SUPPLY (SEE PARA 5-19). IF REGULATION IS BAD, PROCEED TO TABLE 5-2
CHECK THAT NEGATIVE SUPPLY OUTPUT TRACKS OUTPUT OF POSITIVE SUPPLY WHEN ±15V ADJ (A3R11) IS ADJUSTED
DOES NEG OUTPUT TRACK POS OUTPUT?
YES
END
NO
IS OUTPUT OF NEG SUPPLY HIGH OR LOW OR ZERO?
HIGH
LOW OR ZERO
TURN (-) CURRENT LIMIT ADJ. (A3R23) FULLY CLOCKWISE AND RECHECK WHETHER NEG OUTPUT TRACKS POS OUTPUT
DOES NEG OUTPUT TRACK POS OUTPUT?
YES
CHECK SETTING OF (-) CURRENT LIMIT ADJUSTMENT CHECK U2
NO
OUTPUT >+18V
OUTPUT LOW OR ZERO
CHECK FOR SHORTED A3Q4, Q5 OR DEFECTIVE U2 (NOTE 2)
CHECK FOR OPEN A3Q4, Q5, U4, SHORTED C10, C11, C16, C17, CR2, R23 OR DEFECTIVE U2 (NOTE 2)
NOTES
1. MAKE SURE THAT THE +15V SUPPLY IS OPERATING PROPERLY BEFORE ATTEMPTING TO TROUBLESHOOT THE -15V SUPPLY
2. AN A3U1 FAILURE MAY CAUSE A3Q5 TO FAIL. AN A3U2 FAILURE MAY CAUSE A3Q2 TO FAIL

Figure 5-10. A3 Board Troubleshooting Procedure

SECTION VI
REPLACEABLE PARTS

6-1 INTRODUCTION

6-2 This section contains information for ordering replacement parts. Table 6-3 lists parts in alpha-numeric order by reference designators and provides the following information:

a. Reference Designators. Refer to Table 6-1.

b. Description. Refer to Table 6-2 for abreviations.

c. Total Quantity (TQ). Given only the first time the part number is listed except in instruments containing many sub-modular assemblies, in which case the TQ appears the first time the part number is listed in each assembly.

d. Manufacturer's Part Number or Type.

e. Manufacturer's Federal Supply Code Number.

f. Hewlett-Packard Part Number.

g. Recommended Spare Parts Quantity (RS) for complete maintenance of one instrument during one year of isolated service.

h. Parts not identified by a reference designator are listed at the end of Table 6-3 under Mechanical and/or Miscellaneous. The former consists of parts belonging to and grouped by individual assemblies; the latter consists of all parts not immediately associated with an assembly.

6-3 ORDERING INFORMATION

6-4 To order a replacement part, address order or inquiry to your local Hewlett-Packard sales office (see lists at rear of this manual for addresses). Specify the following information for each part: Model, complete serial number, and any Option or special modification (J) numbers of the instrument; Hewlett-Packard part number; circuit reference designator; and description. To order a part not listed in Table 6-3, give a complete description of the part, its function, and its location.

Table 6-1. Reference Designators

A	= assembly	E	= miscellaneous electronic part
B	= blower (fan)	F	= fuse
C	= capacitor	J	= jack, jumper
CB	= circuit breaker	K	= relay
CR	= diode	L	= inductor
DS	= device, signaling (lamp)	M	= meter

Table 6-1. Reference Designators (Continued)

P	= plug	V	= vacuum tube, neon bulb, photocell, etc.
Q	= transistor, SCR	VR	= zener diode
R	= resistor	X	= socket
S	= switch	U	= integrated circuit or network
T	= transformer		
TB	= terminal block		
TS	= thermal switch		

Table 6-2. Description Abbreviations

A	= ampere	mod.	= modular or modified
ac	= alternating current	mtg	= mounting
assy.	= assembly	n	= nano = 10^{-9}
bd	= board	NC	= normally closed
bkt	= bracket	NO	= normally open
°C	= degree Centigrade	NP	= nickel-plated
cd	= card	Ω	= ohm
coef	= coefficient	obd	= order by description
comp	= composition	OD	= outside diameter
CRT	= cathode-ray tube	p	= pico = 10^{-12}
CT	= center-tapped	P.C.	= printed circuit
dc	= direct current	pot.	= potentiometer
DPDT	= double pole, double throw	p-p	= peak-to-peak
DPST	= double pole, single throw	ppm	= parts per million
elect	= electrolytic	pvr	= peak reverse voltage
encap	= encapsulated	rect	= rectifier
F	= farad	rms	= root mean square
°F	= degree Farenheit	Si	= silicon
fxd	= fixed	SPDT	= single pole, double throw
Ge	= germanium	SPST	= single pole, single throw
H	= Henry	SS	= small signal
Hz	= Hertz	T	= slow-blow
IC	= integrated circuit	tan.	= tantulum
ID	= inside diameter	Ti	= titanium
incnd	= incandescent	V	= volt
k	= kilo = 10^{3}	var	= variable
m	= milli = 10^{-3}	ww	= wirewound
M	= mega = 10^{6}	W	= Watt
μ	= micro = 10^{-6}		
met.	= metal		
mfr	= manufacturer		

Table 6-3. Replaceable Parts

A1 Board 61005E and 61315E

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
C1	Fxd elect 500μf 150V	2	(Type68D)D40701	56289	0180-1889
C2	Fxd elect 500μF 150V			28480	0180-1889
C3	Fxd cer. .05μf 400V	1	33C17A3-CDH	56289	0150-0052
C4	Fxd mica 30pf 500V	1	Obd	72136	0140-0203
C5	Fxd elect 10μf 20V	3	150D106X9020B2	56289	0180-0374
C6	Fxd cer. 1000pf 1kV	1	C067B102E102ZS26	56289	0150-0050
C7	Fxd elect 10μf 20 V		150D106X9020B2	56289	0180-0374
C8	Fxd mica 2000pf 100V	1	Obd	72136	0160-2301
C9	Fxd cer .01μf 100V	2	TA	91418	0150-0093
C10	fxd polyester .068μf 200V	1	292P68392	56289	0160-0166
C11	Fxd polyester 2200pf 200V	1	AE12C222KT	06001	0160-0154
C12	Fxd cer 5000pf 100V	1		28480	0160-2639
C13	fxd elect 180μf 40V	1	672D119-DSY	56289	0180-2606
C14	Fxd elect 10μf 20V		150D106X9020B2	56289	0180-0374
C15	Fxd cer 5000pf 1kV	1	C023B102G502ZS31	56289	0160-0899
C16	Fxd elect 69μf 150V	1	672D120-DSY	56289	0180-2607
C17	Fxd polyester 1μf 600V	1	1041	09134	0170-0073
C18	Fxd cer .01μf 100V		TA	91418	0150-0093
CR1	Diode Si 1.5A 400V	1	SR1846-12	04713	1901-0418
CR2	Diode stabistor 150mA 15V	2	STB523	03508	1901-0460
CR3	(Not Assigned)				
CR4	Diode Power 1mA 400V	3	IN4936		1901-1065
CR5	Diode Power 1mA 400V		IN4936		1901-1065
CR6	Diode, Si, 200mA 80V	7	FDH6308	07263	1901-0050
CR7	Diode, Si, 200mA 80V		FDH6308	07263	1901-0050
CR8	Diode stabistor 150mA 15V		STB523	03508	1901-0460
CR9	Diode, Si 200mA 80V		FDH6308	07263	1901-0050
CR10	Diode, Si 200mA 80V		FDH6308	07263	1901-0050
CR11	Diode Si 1A 100V	2	IN4934		1901-0693
CR12	Diode, Si 200mA 80V		FDH6308	07263	1901-0050
CR13	Diode, Si 200mA 80V		IN4936		1901-1065
CR14	Diode Si 1A 100V		IN4934		1901-0693
CR15	Diode Schottky 10μA 60V	1	HSCH-1001	28480	1901-0841
CR16	Diode, Si 200mA 80V		FDH6308	07263	1901-0050
CR17	Diode, Si 200mA 80V		FDH6308	07263	1901-0050
F1	Fuse 6A 250V Fastblow	1	3102006	75915	2110-0056
J1	Connector (Socket)	5		28480	1251-5708
J2	Connector (female) 10 pin	1	09-52-3103	27264	1251-0628
L1	Inductor 90μH	1		28480	5080-1846
Q1	SSNPN Si	5	2N2222A		1854-0477
Q2	Thyristor (SCR)	1	2N5060		1884-0074
Q3	SSNPN Si		2N2222A		1854-0477
Q4	Transistor Power NPN Si	1		28480	1854-0673
Q5	NPN Power Si	1		28480	1854-0657
Q6	PNP Power Si	1	MJE-210	04713	1853-0398

Table 6-3. Replaceable Parts (cont.)

A1 Board 61005E and 61315E

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
Q7	SSNPN Si		2N2222A		1854-0477
Q8	SSNPN Si	1	MJE-200	04713	1854-0739
Q9	SSNPN Si		2N2222A		1854-0477
Q10-12	SSPNP Si	4	2N2907A		1853-0281
Q13	SSNPN Si		2N2222A		1854-0477
Q14	SSPNP Si		2N2907A		1853-0281
R1	Fxd comp 3.3Ω 5% ½W	1	EB-3365	01121	0686-0335
R2	Fxd film 30.1k 1% 1/8W	1	MF4C-1	19701	0757-0453
R3	Fxd film 3.32k 1% 1/8W	1	MF4C-1	19701	0757-0433
R4	Fxd metal ox 8.2k 5% 2W	1	RG42	11502	0764-0044
R5	Fxd comp 100k 5% ¼W	1	CB-1045	01121	0683-1045
R6	Fxd comp 47k 5% ¼W	1	CB-4735	01121	0683-4735
R7	Fxd comp 10k 5% ¼W	1	CB-1035	01121	0683-1035
R8	Fxd comp 100Ω 5% ½W	1	EB-1015	01121	0686-1015
R9	Fxd comp 100Ω 5% ¼W	2	EB-1015	01121	0683-1015
R10	Fxd ww 750Ω 5% 5W	1	RS-5	91637	0811-1861
R11	Fxd comp 10Ω 5% ½W	1	EB-1005	01121	0686-1005
R12	Fxd film 10k 1% 1/8W	1	MF4C-1	19701	0757-0442
R13	Fxd film 13.3k 1% 1/8W	1	MF4C-1	19701	0757-0289
R14	Fxd comp 47Ω 5% ¼W	3	CB-4705	01121	0683-4705
R15	Fxd comp 120Ω 5% ¼W	1	CB-1215	01121	0683-1215
R16	(Jumper)				
R17	Fxd comp 47Ω 5% ¼W		CB-4705	01121	0683-4705
R18	Fxd comp 51Ω 5% ¼W	1	CB-5105	01121	0683-5105
R19	Fxd comp 2.7Ω 5% ½W		EB-27G5	01121	0686-0275
R20	Fxd comp 1.5k 5% ¼W	1	CB-1525	01121	0683-1525
R21	Fxd comp 18Ω 5% ½W	2	EB-1805	01121	0686-1805
R22	Fxd comp 1Ω 5% 3W	1	RS-2B	91637	0811-1732
R23	Fxd comp 18Ω 5% ½W		EB-1805	01121	0686-1805
R24	Fxd comp 47Ω 5% 1/4W		CB-4705	01121	0683-4705
R25	Fxd comp 430Ω 5% ¼W	1	CB-4315	01121	0683-4315
R26	Fxd comp 820Ω 5% ¼W	1	CB-8215	01121	0683-8215
R27	Fxd comp 1k 5% ¼W	3	CB-1025	01121	0683-1025
R28	Fxd comp 1k 5% ¼W		CB-1025	01121	0683-1025
R29	Fxd film 34.8Ω 1% 1/8W	1	MF4C-1	19701	0698-3434
R30	Fxd film 100Ω 1% 1/8W	1	MF4C-1	19701	0757-0401
R31	Fxd film 1.62k 1% 1/8W	2	MF4C-1	19701	0757-0428
R32	Fxd comp 82Ω 5% ½W	1	EB-8205	01121	0686-8205
R33	Fxd film 1.62k 1% 1/8W		MF4C-1	19701	0757-0428
R34-36	Fxd ww .15Ω 5% 3W	3	RS-2B	91637	0812-0045
R37	Fxd comp 1k 5% ¼W		CB-1025	01121	0683-1025
R38	Fxd comp 100Ω 5% ¼W		EB-1015	01121	0683-1015
R39	Fxd comp. 27k 5% ¼w	1	CB-2735	01121	0683-2735
R41	Fxd comp 100k 5% ¼W		CB-1045	01121	0683-1045
T1	Pulse Transformer	1		28480	5080-1809
TS1	Thermal SW (Opens AT 90°C)	1	430-901	72983	3103-0017
U1	IC linear amp	1	LM301AH	27014	1820-0223
U2	IC linear timer	1	NE555T	18324	1826-0119
U3	Photo-Isolator	1	IL-1	50579	1990-0543

Table 6-3. Replaceable Parts (cont.)

A1 Board 61005E and 61315E

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
VR1	Diode Zener 6.19V 2%	1	SZ10939-123	04713	1902-3114
VR2	Diode Zener 7.5V 5%	1	SZ10939-146	04713	1902-0064
VR3	Diode Zener 6.81V 5%	1	SZ10939-134	04713	1902-0048
VR4	Diode Zener 2.37V 5%	2	SZ10939-2	04713	1902-3002
VR5	Diode Zener 2.37 5%		SZ10939-2	04713	1902-3002
VR6	Diode Zener 28.7V 5%	1	SZ11213-272	04713	1902-0572
VR7	Diode Zener 150V 5%	1	SZ11213-440	04713	1902-0586
	A1 Board 63005E and 63315E				
C1	(Not Assigned)				
C2	Fxd elect 500μf 150V	2	(Type68D)D40701	56289	0180-1889
C3	Fxd elect 500μf 150V		(Type68D)D40701	56289	0180-1889
C4	Fxd elect .01μf 100V	3	TA	91418	0150-0093
C5	Fxd elect 1μf 35V	2	150D105X5035A2-DYS	56289	0180-1980
C6	Fxd elect 1μf 35V		15D105X5035A2-DYS	56289	0180-1980
C7	Fxd elect 22μf 15V	2	150D226X901B2	56289	0180-0228
C8	Fxd cer 500pf 100V	1		28480	0160-2639
C9	Fxd elect 10μf 20V	1	150D106X9020B2	56289	0180-0374
C10	Fxd mica 200pf 100V	1	obd	72136	0160-2301
C11	fxd cer .01μf 100V		TA	91418	0150-0093
C12	Fxd polyester .068μf 200V	1	292P68392	56289	0160-0166
C13	69μf 140 V				0180-2607
C14	Fxd cer 1000pf 100V	2	CAC02X7R102M100A	16299	0160-4556
C15	Fxd elect 180μf 40V	1	672D119-DSY	56289	0180-2606
C16-27	(Not Assigned)				
C28	Fxd cer .05μf 400V	1	33C17A3-CDH	56289	0150-0052
C29	Fxd cer 1000pf 1kV	2	C067B102E102ZS26	56289	0150-0050
C30	Fxd elect 22μf 15V		150D226X9015B2	56289	0180-0228
C31	Fxd cer .01μf 100V		TA	91418	0150-0093
C32	Fxd polyester 1μf 250V	1		28480	0160-4962
C33, 34	Fxd mec 4700pf 250V	2		28480	0160-4439
C35	Fxd cer 1000pf 1kV		C067B102E102ZS26	56289	0150-0050
C36	Fxd cer 1000pf 100V		CAC02X7R102M100A	16299	0160-4556
C37, 38	Fxd dielectric 2200pf 250V	2	PME271Y422	C0633	0160-4281
CR1	Diode 600mA 800V	2		28480	1901-0030
CR2	Diode 600mA 800V			28480	1901-0030
CR3	Diode 3A 850V	2		28480	1901-0930
CR4	Diode 3A 850V			28480	1901-0930
CR5-9	Diode Si 200mA 80V	10	FDH6308	07263	1901-1050
CR10-11	(Not Assigned)				
CR12	Diode Si 1A 400V	3	1N 4936	04713	1901-1065
CR13	Diode Si 200mA 80V		FDH6308	07263	1901-1050
CR14	Diode Si 200mA 80V		FDH6308	07263	1901-1050
CR15	(Not Assigned)				
CR16	Diode Si 200mA 80V		FDH6308	07263	1901-1050
CR17	Diode Si 200mA 80V		FDH6308	07263	1901-1050
CR18	Diode Si 1A 400V		1N4936	04713	1901-1065
CR19	Diode Si 200mA 80V		FDH6308	07263	1901-1050
CR20	Diode Si 1A 100V	1	1N4934	04713	1901-0693

Table 6-3. Replaceable Parts (cont.)

A1 Board 63005E and 63315E

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
CR21	Diode Si 750mA 400V	1	SR1358-9	04713	1901-0028
CR22	Diode Power Rec.	1		28480	1901-1087
CR23	Diode Si 1A 400V		1N4936	04713	1901-1065
F1	Fuse fastblow 5A 250V	1	312005	75915	2110-0010
J1	Connector	1	09-52-3103	27264	1251-5708
J2	Connector female 10 pin	2		28480	1251-0628
L1	(Not Assigned)				
L2	Inductor 1.3mh	1		28480	5080-1961
L3	Choke assy RFI	1		28480	5080-1962
Q1	SCR	2			1884-0302
Q2	SCR				1884-0302
Q3	SS NPN Si	4	2N2222A		1854-0477
Q4	SS NPN Si		2N2222A		1854-0477
Q5	NPN	1			1854-0911
Q6	Power PNP Si	1	MJE-210-04713		1853-0398
Q7	SS NPN Si		2N2222A		1854-0477
Q8-10	PNP Si	5	2N2907	A14433	1853-0281
Q11	SS NPN Si		2N2222A		1854-0477
Q12	PNP Si		2N2907A	14433	1853-0281
Q13	PNP		2N4032		1853-0320
Q14	PNP Si		2N2907A	14433	1853-0281
R1	Fxd 10Ω 5% ¼W	3	CB-1005	01121	0683-1005
R2	Fxd 10Ω 5% ¼W		CB-1005	01121	0683-1005
R3	(Not Assigned)				
R4	Fxd 3.9k 5% 2W	2		28480	0764-0019
R5	Fxd ww 3k 5% 3W	2	VAL-3	24681	0812-0010
R6	Fxd film 4.3k 1% 1/8W	1	MF4C-1	19701	0757-0436
R7	Fxd film 9.09k 1% 1/8W	1	MF7C-1	19701	0757-0288
R8	Fxd film 210k 1% 1/8W	1	C4-1/8-TO-2103-F	24546	0698-4528
R9	Fxd comp 20Ω 5% ¼W	1	CB-2005	01121	0683-2005
R10	Fxd film 1.5k 1% 1/8W	1	C4-1/8-TO-1501-F	24546	0757-0427
R11	Fxd film 33k 5% ¼W	1	CB-3335	01121	0683-3335
R12	Fxd comp 160k 5% ¼W	2	CB-1665	01121	0683-1645
R13	Fxd film 3.3k 5% ¼W	1	CB-3325	01121	0683-3325
R14	Fxd comp 160k 5% ¼W		CB-1645	01121	0683-1645
R15	Fxd comp 1k 5% ¼W	2	CB-1025	01121	0683-1025
R16	Fxd comp 10k 5% ¼W	1	CB-1035	01121	0683-1035
R17	Fxd film 8.2k 2% 1/8W	1	C4-1/8-TO-8201-G	24546	0757-0946
R18	Fxd film 39k 1% 1/8W	1	CMF-551T-1	91637	0968-6076
R19	Fxd film 90.9k 1% 1/8W	1	C4-1/8-TO-9092-F	24546	0757-0464
R20	Fxd film 6.19k 1% 1/8W	1	MF4C1/8-TO-6191-F	19701	0757-0290
R21	Fxd ww 1.5k 5% 3W	2		28480	0811-1805
R22	Fxd comp 100Ω 5% ¼W	2	CB-1015	01121	0683-1015
R23	Fxd film 150Ω 5% ¼W	1	CB-1515	01121	0683-1515
R24	Fxd film 8.25k 1% 1/8W	1	C4-1/8-TO-8251-F	24546	0757-0441
R25	Fxd film 15k 1% 1/8W	1	C4-1/8-TO-1402-F	24546	0698-4479

Table 6-3 Replaceable Parts (cont.)

A1 Board 63005E and 63315E

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
R26	Fxd comp 100Ω 5% ¼W		CB-1015	01121	0683-1015
R27	Fxd carbon 22Ω 5% ¼W	1	EB-2705	01121	0686-2705
R28	Fxd comp 18Ω 5% ½W	1	EB-18005	01121	0686-1805
R29	Fxd comp 820Ω 5% ¼W	2	CB-8215	01121	0683-8215
R30	Fxd carbon 51Ω 5% ¼W	1	CB-5105	01121	0683-5105
R31	Fxd comp 1k 5% ¼W		CB-1025	01121	0683-1025
R32	Fxd comp 430Ω 5% ¼W	1	CB-4315	01121	0683-4315
R33-35	Fxd ww 1Ω 5% 3W	3	RS-2B	91637	0811-1732
R36	Fxd film 2.7k 5% ¼W	1	CB-2725	01121	0683-2725
R37	Fxd ww .1Ω 10% 3W	1	K46505	14841	0811-1827
R38	Fxd film 90.0Ω 1% 1/8W	1	C4-1/8-TO-90R9-F	24546	0757-0400
R39	Fxd film 4.32k 1% ¼W	1	C4-1/8-TO-4321-F		0757-0436
R40	Fxd film 475 1% ¼W	1	C4-1/8-TO-475R-F	24546	0757-0415
R41	Fxd film 1k 1/8W	1	C4-1/8-TO-1001-F	24546	0757-0280
R42	Fxd ww 1.5 5% 3W	1		28480	0811-1220
R43	Fxd ww 3k 1% 1/8W		VAL-3	24681	0812-0010
R44	Fxd film 10Ω 1% ¼W		CB-1005	01121	0683-1005
R45	Fxd ww 10k 5% 3W	1		28480	0811-1816
R46	Fxd comp 39Ω 5% ½W	1	EB-3905	01121	0686-3905
R47	Fxd metal 3.9k 5% 2W				0764-0019
R48	Fxd film 18Ω 5% ¼W	2	CB-1805	01121	0683-1805
R49	Fxd film 18Ω 5% ¼W		CB-1805	01121	0683-1805
R50	Fxd comp 22Ω 5% ½W	1	CB-2205	01121	0686-2205
R51	Fxd ww 1.5k 5% 3W			28480	0811-1805
R52	Fxd film 27Ω 5% ¼W	1	CB-2705	01121	0683-2705
R53	Fxd film 6.2k 5% ¼W	1	CB-6225	01121	0683-6225
R54	Fxd comp 820Ω 5% ¼W		CB-8215	01121	0683-8215
R55	Fxd film 39.2Ω 1% 1/8W	1	C4-1/8-TO-39R2-F	24546	0757-0391
R56	Fxd film 100kΩ 5% ¼W	1			0683-1045
R57	Fxd comp 9.1k 5% ¼W	1	CB-9125	01121	0683-9125
RV1	Varistor	2	G-41A14	83186	0837-0117
RV2	Varistor		G-41A14	83186	0837-0117
RV3	Varistor	1			0837-0221
T1	Transformer (Pulse)	1	28480		5080-1785
T2	Transformer (Pulse)	1	28480		5080-1959
TS1	Terminal SW Open at 230°F	1		28480	3103-0049
U1	IC-Thyristor-Transistor Array	1	CA3097E	02735	1858-0046
U2	IC-Timer	1	MC1455P1	04713	1826-0180
U3	IC-Isolator 2%	1		28480	1990-0758
VR1	Diode Zener 6.19V 2%	1		28480	1902-1377
VR2	Diode Zener 14V 5%	1		28480	1902-0040
VR3	Diode Zener 75V 5%	3		28480	1902-0661
VR4	Diode Zener 75V 5%		CO35754	04713	1902-0661
VR5	Diode Zener 75V 5%		SZ11213-3S2	04713	1902-0661
VR6	Diode Zener 4.3V 5%	1		28480	1902-1363

Table 6-3. Replaceable Parts (cont.)

A2 Board

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
C1	Fxd elect 47μf 40V	1		28480	0180-2827
C2	Fxd elect 2.2μf 20V	4	150D225X0020A2	56289	0180-0155
C3					
61005E 61315E	Fxd cer 0.1μf 50V	1	5C50B1-CML	56289	0150-0121
63005E 63315E	(Not Used)				
C4	Fxd polyester .022μf 200V	2	AE17C223KT	06001	0160-0162
C5	Fxd elect 2000μf 10V		302G52020U010B	00853	0180-2624
C6	(Not Assigned)				
C7	Fxd elect 2.2μf 20V		150D225X0020A2	56289	0180-0155
C8	Fxd elect 2.2μf 20V		150D225X0020A2	56289	0180-0155
C9	Fxd elect 22μf 15V		150D226X9015B2	56289	0180-0228
C10	Fxd elect 4.7μf 35V	1	150D475X9035B2	56289	0180-0100
C11	Fxd elect 2.2μf 20V	1	150D225X0020A2	56289	0180-0155
C12	Fxd elect 2000μf 10V		302GJ202U010B	00853	0180-2624
C13	(Not Assigned)				
C14	Fxd polyester .022μf 200V		AE17C223KT	06001	0160-0162
C15	Fxd cer .1μf 50V	1	5C50B1-CML	56289	0150-0121
C16					
61005E 61315E	Fxd cer 2.2μf 50V	1	5C15C2-CML	56289	0160-0128
63005E 63315E	Fxd cer 1.0μf 25V	2	5C15C2-CML	56289	0160-0127
C17-19	Fxd cer .05μf 400V		33C17A3-CDH	56289	0150-0052
C20					
61005E 61315E	Fxd cer 1000pf 1kV	1	C067B102E102ZS26	56289	0150-0050
63005E 63315E	(Not Used)				
C21					
61005E 61315E	(Not Used)				
63005E 63315E	Fxd cer 0.1μf 50V		5C50B1-CML	56289	0150-0121
C22, C23					
61005E 61315E	(Not Used)				
63005E 63315E	Fxd cer 2.2μf 50V	1	5C15C2-CML	56289	0160-0128
C24 C25	(Not Used)				
61005E 61315E	Fxd elect 1μf 35V	1	150D105X9035A2	56289	0180-0291
63005E 63315E	(Not Used)				

Table 6-3. Replaceable Parts (cont.)

A2 Board

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
C26	Fxd cer 2200pf 200V	2		28480	0160-2289
C27	Fxd cer .01μf 100V	1		28480	0150-0093
C28	Fxd cer 5000pf 100V	1		28480	0160-2639
C29	Fxd cer 2200pf 200V			28480	0160-2289
CR1	Diode Power 1A 400V	1	IN4936	14936	1901-1065
CR2	Diode Switching 200mA 80V	3		28480	1901-0050
CR3	(Not Assigned)				
CR4,5	Diode switching 200mA 80V		FDH6308	07263	1901-0050
CR6					
61005E 61315E	Diode Power 1A 400V		IN4936	04713	1901-1065
63005E 63315E	Diode Switching 200mA 80V		FDH6308	07263	1901-0050
CR7	Diode Switching 200mA 80V		FDH6308	07263	1901-0050
L1	Choke 280μh	1		28480	5080-1963
L2	Core mag 1.2μh	2		28480	9170-0894
L3	Consists of:				
	Coil - 22A	1		28480	5080-1967
	Core magnetic	1		28480	9170-1116
L4				28480	
61005E 61315E	(Not Used)				
63005E 63315E	Core mag. 1.2μh				9170-0894
P1	Connector male 10 pin	1	09-64-1103	27264	1251-0269
61005E 63005E	Not Assigned				
61315E 63315E	Connector male 10 pin	1	09-64-1103	27264	1251-0269
Q1	Thyristor SCR	1	MCR69-2	04713	1884-0293
Q2	Transistor PNP	1	2N2907A	14433	1853-0281
R1					
61005E 61315E	Fxd film 2.7μ 5% ¼W	1	CB27G5	01121	0683-0275
63005E 63315E	(Not Used)				
R2	Fxd comp 470Ω 5% ½W	1	CB-4715	01121	0686-4715
R3	Fxd comp 75Ω 5% ½W	1	EB-7505	01121	0686-7505
R4	Fxd film 1.33k 1% 1/8W	2	C4-1/8-TO-1331-F	25546	0757-0317
R5	Fxd film 2.15k 1% 1/8W	1	C4-1/8-TO-2151-F	24546	0698-0084
R6	Fxd film 6.19k 1% 1/8W	1	MF4C-1/8-TO-6191-F	19701	0757-0290
R7	Fxd comp 3k 5% ¼W	1	CB-3025	01121	0683-3025
R8	Fxd comp 470 5% ¼W	3	CB-4715	01121	0683-4715
R9	Fxd comp 3.3Ω 5% ¼W	1	CB-33G5	01121	0683-0335
R10	Fxd film 2.37k 1% 1/8W	1	MF4C-1	19701	0698-3150
R11	Fxd comp 68k 5% ¼W	1	CB-6835	01121	0683-6835
R12	Fxd film 4.32k 1% 1/8W	1	MF4C-1	19701	0757-0436
R13	Fxd film 3k 1% 1/8W	2	MF4C-1	19701	0757-1093
R14	Fxd film 82k 5% ¼W	2	CB-8235	01121	0683-8235

Table 6-3. Replaceable Parts (cont.)

A2 Board

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
R15	Fxd film 3k 1% 1/8W	2	MF4C-1	19701	0757-1093
R16	Fxd comp 470Ω 5% ¼W		CB-4715	01121	0683-4715
R17	Fxd film 6.49k 1% 1/8W	1			0698-3226
R18	Fxd film 1.43k 1% 1/8W	1	C4-1/8-TO-1431-F	24546	0698- 3225
R19	Fxd film 21.5k 1% 1/8 W	2	MF4C-1	19701	0757-1099
R20	Fxd film 12.7Ω 1% 1/8W	1		28480	0698-4356
R21	Fxd film 21.5k 1% 1/8W		MF4C-1	19701	0757-0199
R22	Fxd film 600Ω 5% ¼W	1	CB-6815	01121	0683-6815
R23	Fxd comp 470Ω 5% ¼W		CB-4715	01121	0683-4715
R24	Res. Sen 2.35mΩ	1		28480	62515 -8001
R25	Fxd film 82k 5% ¼W		CB-8235	01121	0683-8235
R26	Fxd film 120Ω 5% ¼W	1	CB-1215	01121	0683-1215
R27	Fxd ww 5Ω 5% 10W	1	247E	56289	0811-1893
R28	Fxd film 3.32k 1% 1/8W	2	MF4C-1	19701	0757-0433
R29	Fxd wire .0125			28480	5080-1939
R30	Fxd film 3.32k 1% 1/8W		MF4C-1	19701	0757-0433
R31	Var 2k 10% 1/8W	1	72XR2k	73138	2100-3273
R32	Fxd film 1.33k 1% 1/8W	1	CEA-993	07716	0757 -0317
R33	Fxd film 5.62k 1% 1/8W	1	MF4C-1	19701	0757-0200
R34	Var 5k 10% 1/8W	1	3386X-502	32997	2100-3207
R35	Fxd comp 1k 5% ¼W	1	CB1025	01121	0683-1025
R36	Fxd film 68Ω 5% ¼W	1	CB-6805	01121	0683-6805
R37	Fxd comp 10Ω 5% ¼W	1	CB-1005	01121	0683-1005
R38-39	Fxd comp 27Ω 5% ¼W	3	CB-2705	01121	0683-2705
R40-42	(Not Assigned)				
R43	Fxd film 499Ω 1% 1/8W	1	C4-1/8-TO-499R-F	24546	0698-4123
R44	Fxd film 1k 1% 1/8W		C4-1/8-TO-1001-F	24546	0757-0280
R45	Fxd film 5% ¼W		CB-2705	01121	0683-2705
R46					
61005E 61315E	(Not Used)				
63005E 63315E	Fxd comp 2.7Ω 5% ½W	1	CB-2705	01121	0686-0275
R47					
61005E 61315E	(Not Used)				
63005E 63315E	Fxd comp 8.2Ω 5% ½W	1	EB-82G5	01121	0698-5479
R48-50	(Not Assigned)				
R51	Fxd comp 150Ω 5% ¼W				0683-1515
T1	Core coated	1		28480	5080-1960
T2	Power transformer (Model 63005E)	1		28480	63005-80091
T2	Power transformer (Model 61005E)	1		28480	63315-80091
T2	Power transformer (Model 63315E)	1		28480	63315-80091
T2	Power transformer (Model 61315E)	1		28480	61315-80090

Table 6-3. Replaceable Parts

A2 Board

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
U1	IC-Timer	1	NE555P	1295	1826-0180
U2 61005E 61315E	diode CT Rect 400V 30A	1		28480	1906-0227
63005E 63315E	Diode CT Rect 45V 30A	1	VSK3040T	1B546	1906-0238
U3	Transistor Array NPN	1	CA3146 F	32L585	1858-0032
U4	Voltage Regulator 150mA	1	UA 723CJ	1295	1826-0049
VR1	Diode Zener 10V 5%	1	CD35706	15818	1902-0025
VR2	Diode Zener 5.62V 5%	1		28480	1902-3104
VR3	Diode Zener 47V 5%	1		28480	1902-1361
VR4	Diode Zener 18V 5%	1		28480	1902-1362
VR5	Diode Zener 7.5V 5%	1		28480	1902-0064
	A3 Board 61315E and 63315E				
C1	Fxd cer 5000pf 1kV	2	C023B102G502ZS31	56289	6160-0899
C2	Fxd elect 1800μf 30V	2	066JJ182U030B	00853	0180-2643
C3	Fxd cer .1μf 50V	2	5C50B1-CML	56289	0150-0121
C4	Fxd mylar .022μf 200V	2	AE17C223KT	06001	0160-0162
C5	Fxd elect 2.2μf 20V	2	150D225X0020A2	56289	0180-0155
C6	Fxd cer .01μf 100V	4	TA	91418	0150-0093
C7	Fxd cer .01μf 100V		TA	91418	0150-0093
C8	Fxd elect 180μf 40V	2	672D	56289	0180-2606
C9	Fxd cer .47μf 25V	2	SC11B7-CML	56289	0160-0174
C10	Fxd cer 5000pf 1kV	2	C023B102G502ZS31	56289	0160-0899
C11	Fxd elect 1800μf 30V		066JJ182U030B	00853	0180-2643
C12	Fxd mylar .022μf 200V		AE17C223KT	06001	0160-0162
C13	Fxd cer .01μf 100V		TA	91418	0150-0093
C14	Fxd cer .01μf 100V		TA	91418	0150-0093
C15	Fxd elect .22μf 20V		150D225X0020A2	56289	0180-0155
C16	Fxd elect 180μf 40V		672D	56289	0180-2606
C17	Fxd cer .47μf 25V		5C11B7-CML	56289	0160-0174
C18	Fxd cer .01μf 1kV	1	C023A102J103MS38	56289	0150-0012
C19	Fxd cer .01μf 50V		50B1-CML	56289	0150-0121
C20-21	Fxd cer .05μf 600V	2	33C17A3-CDH	56289	0150-0052
CR1-2	Diode Power 3A 600V	2	IN5406	14936	1901-0759
J1	Connector female 10 pin	1		28480	1251-3361
L1,2	Inductor	2		28480	5080-1847
L3,4	(Not Assigned)				
L5,6	Inductor toroidal	2		28480	5080-1808
Q1	Power NPN	2			1854-0563
Q2	Consists of:				
	HT-DSPR TO-36	2		28480	1205-0037
	Core-Shld Bead	2		28480	9170-0894
	Transistor PNP	3	2N2907A	14433	1853-0281
Q3	Transistor PNP	2	2N2907A	14433	1853-0281
Q4	Power NPN	2			1854-0563
Q5	Consists of:				
	HT-DSPR TO-36			28480	1205-0037
	core-Shldbead			28480	9170-0894
	Transistor PNP		2N2907A	14433	1853-0281

Table 6-3. Replaceable Parts (cont.)

A3 Board 61315E and 63315E

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
Q6	Thrysitor-SCR	1	MCR69-2	04713	1884-0293
Q7	Transistor PNP		2N2907A	14433	1853-0281
R1	Fxd comp 6.8Ω 5% ¼W	2	EB2705	01121	0686-2705
R2-3	Fxd comp 39Ω 5% ¼W	2	EB-3905	01121	0683-3905
R4	Fxd comp 390Ω 5% ¼W	2	CB-3915	01121	0683-3915
R5	Fxd comp 56Ω 5% ¼W	2	EB-5605	01121	0683-5605
R6	Fxd comp 18k 2% 1/8W	1	C4-1/8-TO-1802-G	24546	0757-0954
R7	Fxd ww .39Ω 10% 5W	2		28480	0811-3416
R8	Fxd comp 100Ω 5% ½W	2	EB-51G5	01121	0683-1015
R9	Var trmr 2k 10%	3	72XR2K	73138	2100-3273
R10	Fxd comp 2.2k 5% ½W	1	EB-2225	01121	0683-2225
R11	Var trmr 2k 10%		72XR2K	73138	2100-3273
R12	Fxd film 1k 1% 1/8W	3	CEA-993	07716	0757-0280
R13	Fxd film 2k 1% 1/8W	1	CEA-993	07716	0757-0283
R14	Fxd film 1k 1% 1/8W		CEA-993	07716	0757-0280
R15	Fxd comp 4.7Ω 5% ¼W	2	CB-47G5	01121	0683-0475
R16	Fxd comp 220Ω 5% 2W	3	EB-2205	01121	0686-2205
R17	Fxd comp 220Ω 5% 2W	2	BWH2-221-J	75042	0811-1763
R18	Fxd comp 6.8Ω 5% ½W		EB-2705	01121	0686-2705
R19	Fxd comp 390Ω 5% ¼W		CB-3915	01121	0683-3915
R20	Fxd comp 56Ω 5% ¼W		EB-5605	01121	0683-5605
R21	Fxd comp 27k 5% ¼W		EB-2735	01121	0683-2735
R22	Fxd ww .39Ω 10% 5W			28480	0811-3416
R23	Var trmr 2k 10%		72XR2K	73138	2100-3273
R24	Fxd comp 100Ω 5% ¼W		EB-51G5	01121	0683-1015
R25	Fxd comp 3k 5% ¼W	1	EB-3025	01121	0683-3025
R26	Fxd comp 270Ω 5% ½W	2	EB-2715	01121	0686-2715
R27-28	Fxd film 8.25k 5% 1/8W	2		28480	0698-3328
R29	Fxd film 4.12k 1% 1/8W	1	C4-1/8-TO-4121-F	24546	0698-3493
R30	Fxd comp 270Ω 5% ½W		EB-2715	01121	0683-2715
R31	Fxd comp 150Ω 5% ¼W	1	CB-1515	01121	0683-1515
R32	Fxd comp 22Ω 5% ½W		EB-2205	01121	0686-2205
R33	(Not Assigned)				
R34	Fxd film 681Ω 1% 1/8W	2	MF4C-1	19701	0757-0419
R35	Fxd comp 8.2Ω 5% ½W	1	EB-82G5	01121	0698-5479
R36	Fxd comp 220Ω 5% 2W		BWH2-221-J	75042	0811-1763
R37	Fxd comp 22Ω 5% ½W		EB-2205	01121	0606-2205
R38	Fxd comp 4.7Ω 5% ¼W		CB47G5	01121	0683-0475
R39	Fxd film 681Ω 1% 1/8W		C4-1/8-TO-619R-F	24546	0751-0419
R40	Fxd film 1k 1% 1/8W		CEA-993	07716	0757-0280
R41-44	(Not Assigned)				
R45	Fxd ww 400 Ω5 % ¼W	1		28480	0811-1857
R46-51	(Not Assigned)				
R52	Fxd film 82Ω 5% ¼W		CB-8205	01121	0683-8205
U1,2	IC-Voltage Regulator	2	VA723CJ	01295	1826-0049
U3,4	Diode Ct Rect 400V 150A			28480	1906-0227
VR1,2	Diode Zener 16.19V 2%	2	SZ10939-123	04713	1902-3114

REF. DESIG.	DESCRIPTION	TQ	MFR.PART NO.	MFR. CODE	HP PART NO.
	A4 Chassis-Electrical (Models 63005E and 63315E only)				
L1	inductor, 16.7mH	1		28480	5080-1966
	A1-Mechanical (Models 61005E and 61315E only)				
	heatsink bracket (Q4, Q5, S1	1		28480	5020-2538
	fuseholder bracket	1		28480	5000-3128
XF1	fuseholder body	1			2110-0564
	fuseholder cap	1			2110-0565
	hex nut, ½-24, fuseholder	1			2110-0569
	lockwasher, fuseholder	1			2420-0006
	heat dissipators (Q6, Q8)	2	6025D	13103	1205-0282
	transistor insulator (Q4, Q5)	2		28480	0340-0503
TB1	barrier block, 8-term.	1		28480	0360-1809
	A1-Mechanical (Models 63005E and 63315E only)				
	heatsink bracket assembly				
	heatsink bracket (Q5, S1)	1		28480	5020-2512
	threaded	1			1530-2030
	heat dissipators, (Q1, 2)	2	6025D	13103	1205-0282
	transistor insulator, molded (Q5)	1		28480	0340-0503
TB1	barrier block, 8-term.	1		28480	0360-0680
	barrier block jumper	2		28480	0360-0523
XF1	fuseholder clips	2	6008-32CN	13060	2110-0269
	terminal tab (A4L1 connections)	3		28480	1251-4180
	A2-Mechanical				
	heatsink bracket assembly				
	heatsink bracket (U2, Q1)	1		28480	5020-2630
	threaded	1			1530-2030
	nut threaded	1			0510-0002
	press in nut	1			0590-0343
	transistor insulator, molded (U2)	1		28480	0340-0503
	transistor insulator, mica (U2)	1	734	08530	0340-0174
	terminal pin	2			1251-0600
TB2	barrier block, 5-term.	1		28480	0360-0681
	barrier block, jumper	2		28480	0360-0523

Table 6-3. Replaceable Parts (cont.)

REF. DESIG.	DESCRIPTION	TQ.	MFR. PART NO.	MFR. CODE	HP PART NO.
	A3-Mechanical (Model 63315E only)				
	heat sink bracket (Q1, Q4)	1		28480	63315-20001
	transistor insulator, molded (Q1, Q4)	2	28480		0340-0503
	transistor insulator, mica (Q1, Q4)	2	734	08530	0340-0174
	heat dissipator (Q2, Q5)	2	TXBF-019-025B	98978	1205-0037
	terminal pin	1		28480	1210-0092
TB3	barrier block, 6-term.	1		28480	0360-0590
	barrier block jumper	3		28480	0360-0523
	mounting nut, right angle	1		28480	1210-0092
	Chassis-Mechanical				
	chassis (Models 61005E and 63005E)	1		28480	5000-3112
	chassis (Models 61315E and 63315E)	1		28480	5000-3113
	cover (Models 61005E and 63005E)	1		28480	61005-00001
	cover (Models 61315E and 63315E)	1		28480	61315-00002
	cover label (Model 61005E)	1		28480	7121-1932
	cover label (Model 61315E)	1		28480	7121-1931
	cover label (Model 63005E)	1		28480	7121-1933
	cover label (Model 63315E)	1		28480	7121-1930
	heatsink (Models 61005E and 63005E)	1		28480	5020-2510
	heatsink (Models 61315E and 63315E)	1		28480	5020-2511
	circuit board spacer rod (Models 61005E and 63005E)	2		28480	5020-2515
	circuit board spacer rod (Models 61315E and 63315E)	2		28480	5020- 2516
	heatsink insulator	2		28480	0340-1024
	barrier block cover	1		28480	0360-0551
	Miscellaneous				
	packing carton	1		28480	9211-1175
	carton filler	1		28480	9220-1421
	carton filler (Models 61005E and 63005E only)	1		28480	9220-1422
	floater pad	45		28480	9220-1423

Note: Power transistors A3Q1 and A3Q4 have no direct commerical replacements. For these transistors, the Models 61315E and 63315E uses RCA 2N3055 transistors that have been selected for the following characteristics:

h_{FE} = 35 min. to 90 max. at I_C of 4A

BV_{CEO} = 75V min.

F_T = 500kHz at I_C of 40mA

SECTION VII
CIRCUIT DIAGRAMS AND COMPONENT LOCATION DIAGRAMS

The schematic diagrams in this section are arranged as follows:

Model	Circuit Board		
	A1	A2	A3
61005E	Fig. 7-4	Fig. 7-8	
61315E	Fig. 7-4	Fig. 7-8	Fig. 7-10
63005E	Fig. 7-6	Fig. 7-8	
63315E	Fig. 7-6	Fig. 7-8	Fig. 7-10

Adjoining each sheet of the schematic is a circuit board component location diagram that shows the locations of the components on that board and also of the circled test points which appear on the schematic. (The most important test points are also marked directly on the backs of the circuit boards!) Major waveforms are also provided as a troubleshooting aid. Refer also to Figure 4-1 for a simplified schematic of the entire power supply.

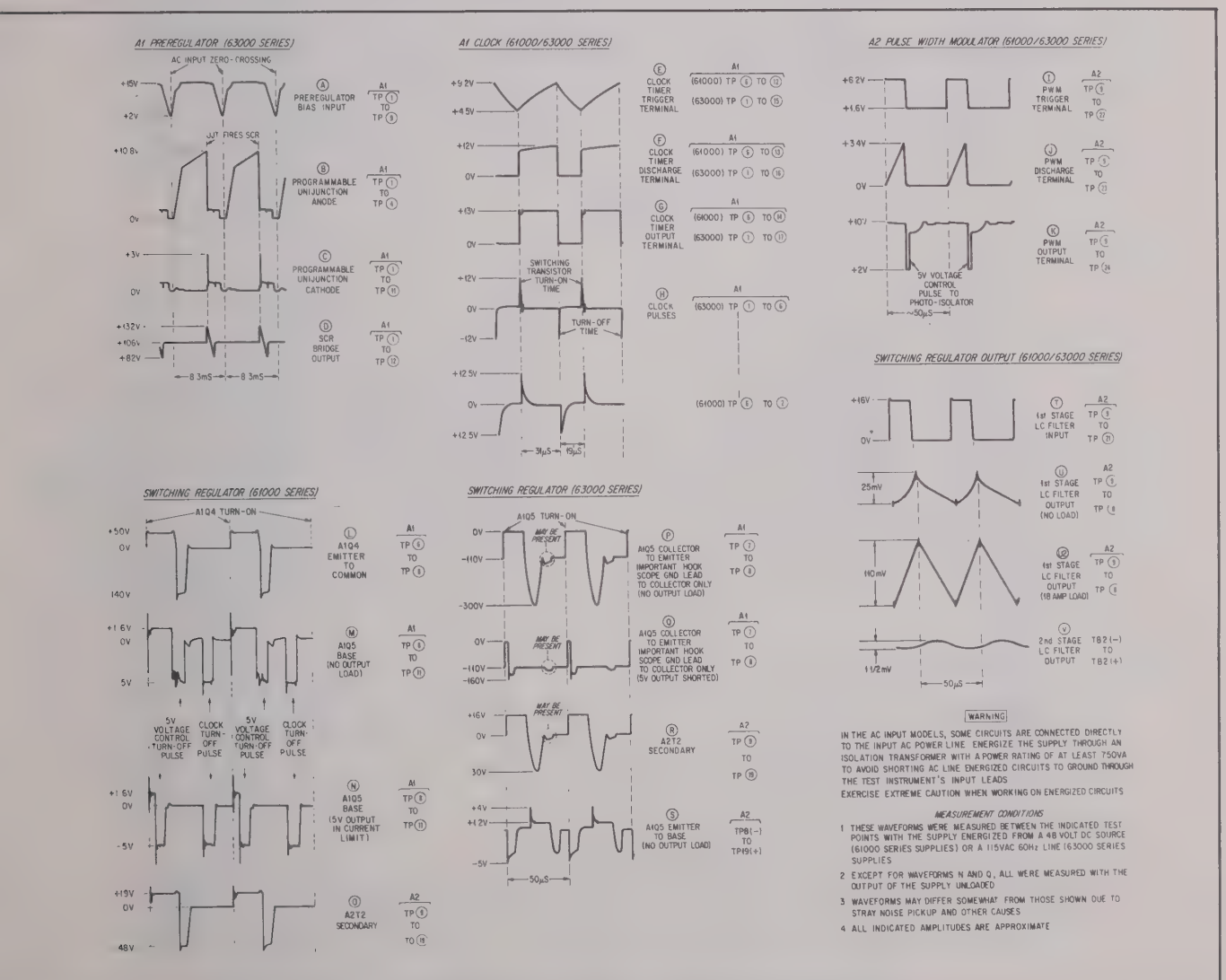

A1 PREREGULATOR (63000 SERIES)
A1 CLOCK (61000/63000 SERIES)
A2 PULSE WIDTH MODULATOR (61000/63000 SERIES)
SWITCHING REGULATOR OUTPUT (61000/63000 SERIES)
SWITCHING REGULATOR (61000 SERIES)
SWITCHING REGULATOR (63000 SERIES)
WARNING
IN THE AC INPUT MODELS, SOME CIRCUITS ARE CONNECTED DIRECTLY TO THE INPUT AC POWER LINE. ENERGIZE THE SUPPLY THROUGH AN ISOLATION TRANSFORMER WITH A POWER RATING OF AT LEAST 750VA TO AVOID SHORTING AC LINE ENERGIZED CIRCUITS TO GROUND THROUGH THE TEST INSTRUMENT'S INPUT LEADS
EXERCISE EXTREME CAUTION WHEN WORKING ON ENERGIZED CIRCUITS
MEASUREMENT CONDITIONS
1 THESE WAVEFORMS WERE MEASURED BETWEEN THE INDICATED TEST POINTS WITH THE SUPPLY ENERGIZED FROM A 48 VOLT DC SOURCE (61000 SERIES SUPPLIES) OR A 115VAC 60Hz LINE (63000 SERIES SUPPLIES
2 EXCEPT FOR WAVEFORMS N AND Q, ALL WERE MEASURED WITH THE OUTPUT OF THE SUPPLY UNLOADED
3 WAVEFORMS MAY DIFFER SOMEWHAT FROM THOSE SHOWN DUE TO STRAY NOISE PICKUP AND OTHER CAUSES
4 ALL INDICATED AMPLITUDES ARE APPROXIMATE

Figure 7-1. Waveforms

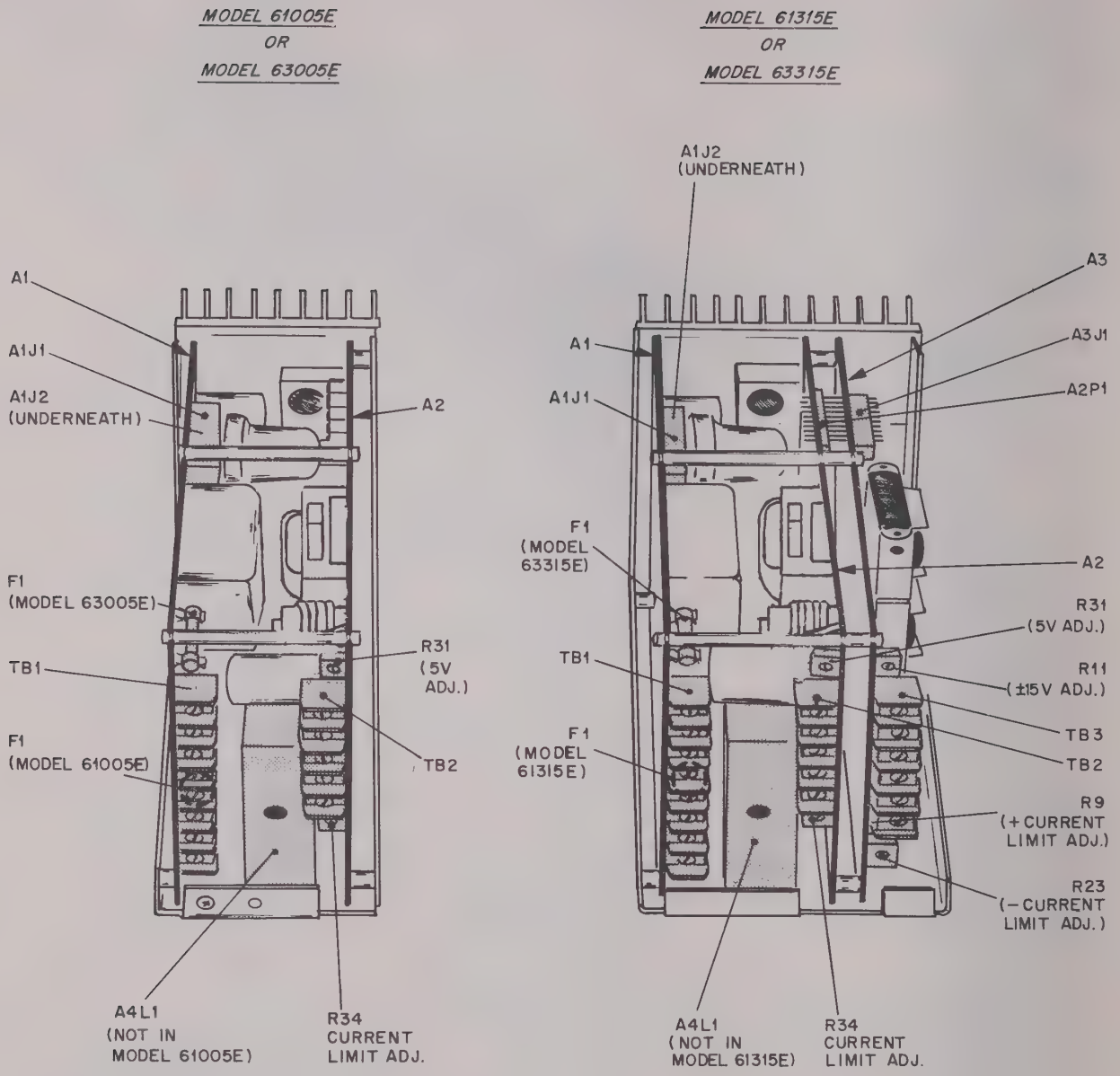
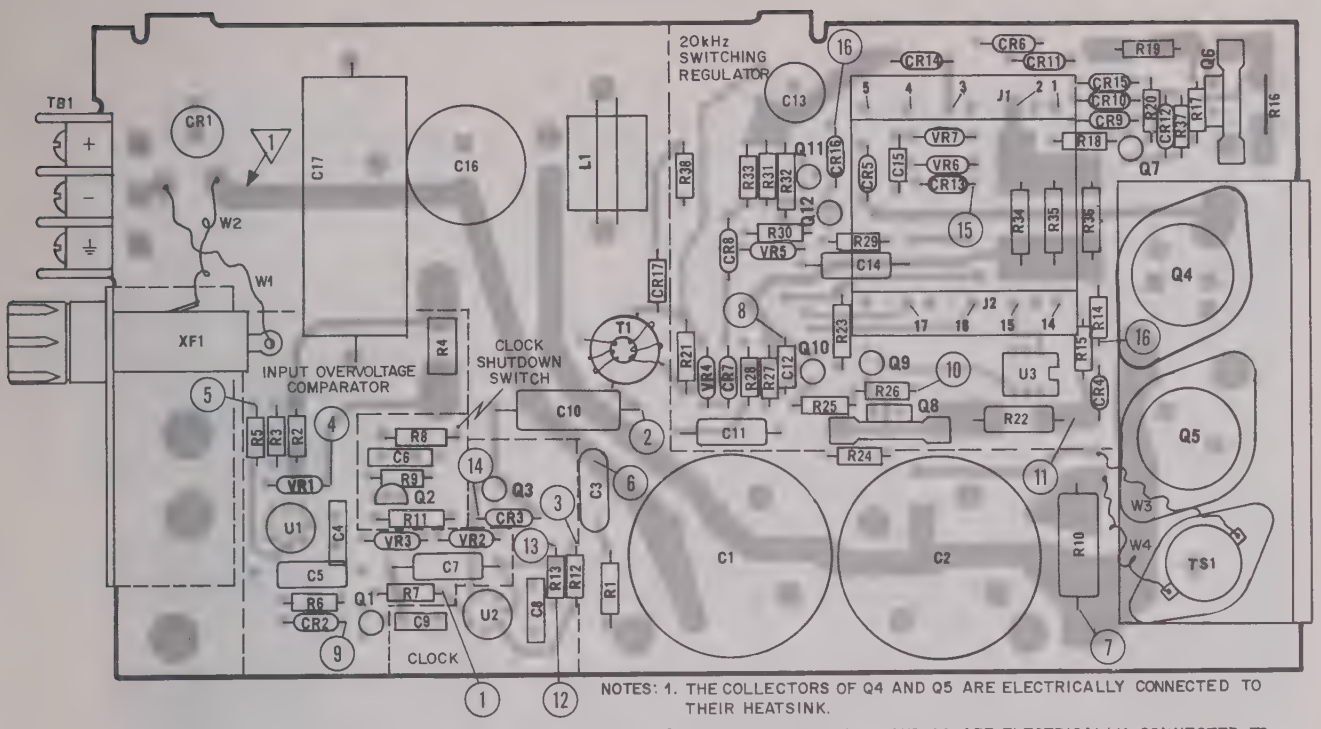


Figure 7-2. Component Locations

(COMPONENT SIDE)



NOTES: 1. THE COLLECTORS OF Q4 AND Q5 ARE ELECTRICALLY CONNECTED TO THEIR HEATSINK.

2. THE COLLECTORS OF Q6 AND Q8 ARE ELECTRICALLY CONNECTED TO THEIR HEATSINKS.

(CIRCUIT SIDE)

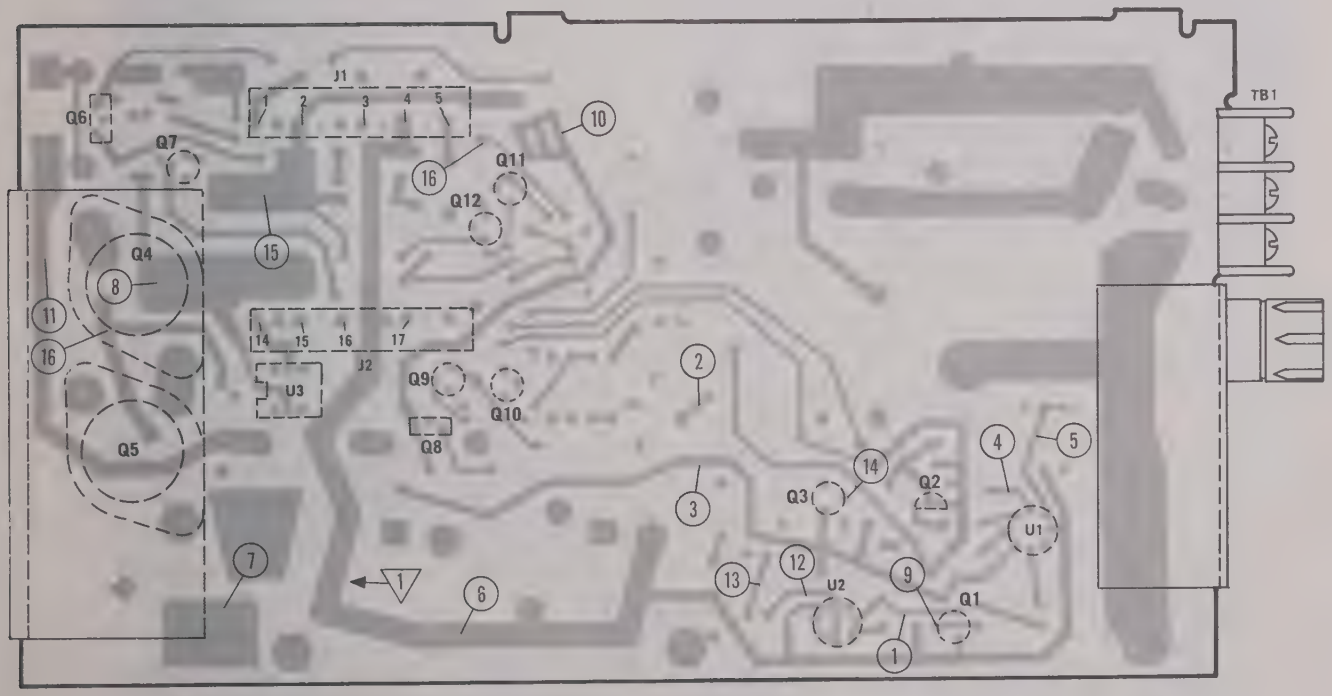


Figure 7-3. A1 DC–DC Converter Assembly, Component Locations

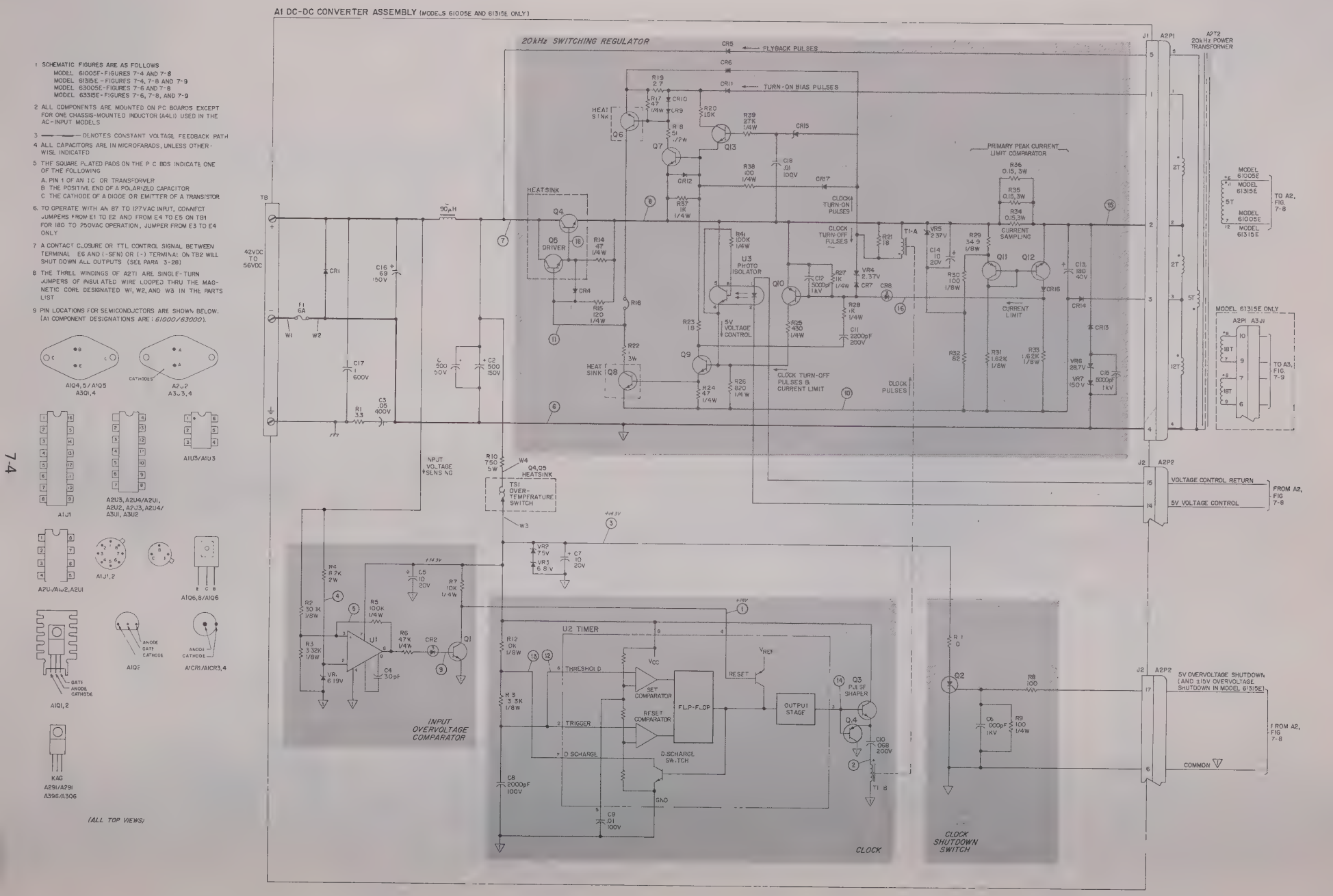
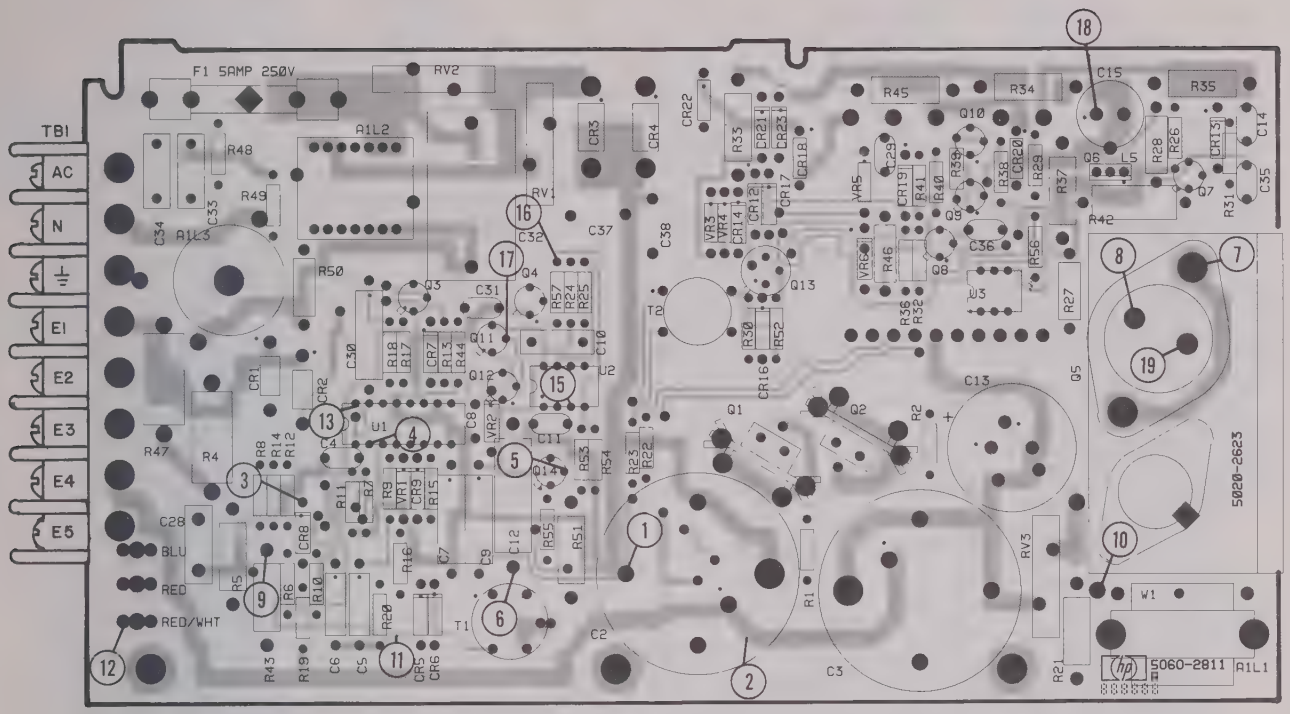

A1 DC-DC CONVERTER ASSEMBLY (MODELS 61005E AND 61315E ONLY)
20kHz SWITCHING REGULATOR
1 SCHEMATIC FIGURES ARE AS FOLLOWS
MODEL 61005E-FIGURES 7-4 AND 7-8
MODEL 61315E - FIGURES 7-4, 7-8 AND 7-9
MODEL 63005E-FIGURES 7-6 AND 7-8
MODEL 63315E-FIGURES 7-6, 7-8, AND 7-9
2 ALL COMPONENTS ARE MOUNTED ON PC BOARDS EXCEPT FOR ONE CHASSIS-MOUNTED INDUCTOR (A4L1) USED IN THE AC-INPUT MODELS
3 DENOTES CONSTANT VOLTAGE FEEDBACK PATH
4 ALL CAPACITORS ARE IN MICROFARADS, UNLESS OTHERWISE INDICATED
5 THE SQUARE PLATED PADS ON THE P C BDS INDICATE ONE OF THE FOLLOWING
A. PIN 1 OF AN IC OR TRANSFORMER
B THE POSITIVE END OF A POLARIZED CAPACITOR
C THE CATHODE OF A DIODE OR EMITTER OF A TRANSISTOR
6. TO OPERATE WITH AN 87 TO 127VAC INPUT, CONNECT JUMPERS FROM E1 TO E2 AND FROM E4 TO E5 ON TB1 FOR 180 TO 250VAC OPERATION, JUMPER FROM E3 TO E4 ONLY
7 A CONTACT CLOSURE OR TTL CONTROL SIGNAL BETWEEN TERMINAL E6 AND (-SEN) OR (-) TERMINAL ON TB2 WILL SHUT DOWN ALL OUTPUTS (SEE PARA 3-28)
8 THE THREE WINDINGS OF A2T1 ARE SINGLE-TURN JUMPERS OF INSULATED WIRE LOOPED THRU THE MAGNETIC CORE DESIGNATED W1, W2, AND W3 IN THE PARTS LIST
9 PIN LOCATIONS FOR SEMICONDUCTORS ARE SHOWN BELOW. (A1 COMPONENT DESIGNATIONS ARE: 61000/63000).
A1Q4, 5/A1Q5 A3Q1, 4
A2...2 A3...3, 4
A1U3/A1U3
A1J1
A2U3, A2U4/A2U1, A2U2, A2U3, A2U4/A3U1, A3U2
A2U1/A1U2, A2U1
A1J1, 2
A1Q6, 8/A1Q6
A1Q2
A1CR1/A1CR3, 4
A1Q1, 2
A2S1/A2S1 A3S6/A3S6
(ALL TOP VIEWS)
INPUT OVERVOLTAGE COMPARATOR
U2 TIMER
CLOCK
CLOCK SHUTDOWN SWITCH
PRIMARY PEAK CURRENT LIMIT COMPARATOR
CURRENT SAMPLING
CURRENT LIMIT
5V VOLTAGE CONTROL
CLOCK TURN-OFF PULSES & CURRENT LIMIT
CLOCK PULSES
HEATSINK
FLYBACK PULSES
TURN-ON BIAS PULSES
CLOCK TURN-ON PULSES
CLOCK TURN-OFF PULSES
INPUT VOLTAGE SENSING
Q4,Q5 HEATSINK
TS1 OVER-TEMPERATURE SWITCH
A2T2 20kHz POWER TRANSFORMER
MODEL 61005E
MODEL 61315E
TO A2, FIG. 7-8
MODEL 61315E ONLY
TO A3, FIG. 7-9
VOLTAGE CONTROL RETURN
5V VOLTAGE CONTROL
FROM A2, FIG 7-8
5V OVERVOLTAGE SHUTDOWN (AND ±15V OVERVOLTAGE SHUTDOWN IN MODEL 61315E)
COMMON
42VDC TO 56VDC

Figure 7-4. A1 DC—DC Converter Assembly, Models 61005E and 61315E

(COMPONENT SIDE)



NOTES: 1. THE ANODES OF SCR'S Q1 AND Q2 ARE ELECTRICALLY CONNECTED TO THEIR HEATSINKS.
2. THE COLLECTOR OF Q5 IS ELECTRICALLY CONNECTED TO ITS HEATSINK.
3. THE FERRITE BEAD ON THE Q6 EMITTER LEAD IS DESIGNATED L4.

(CIRCUIT SIDE)

Figure 7-5. A1 AC–DC Converter Assembly, Component Locations

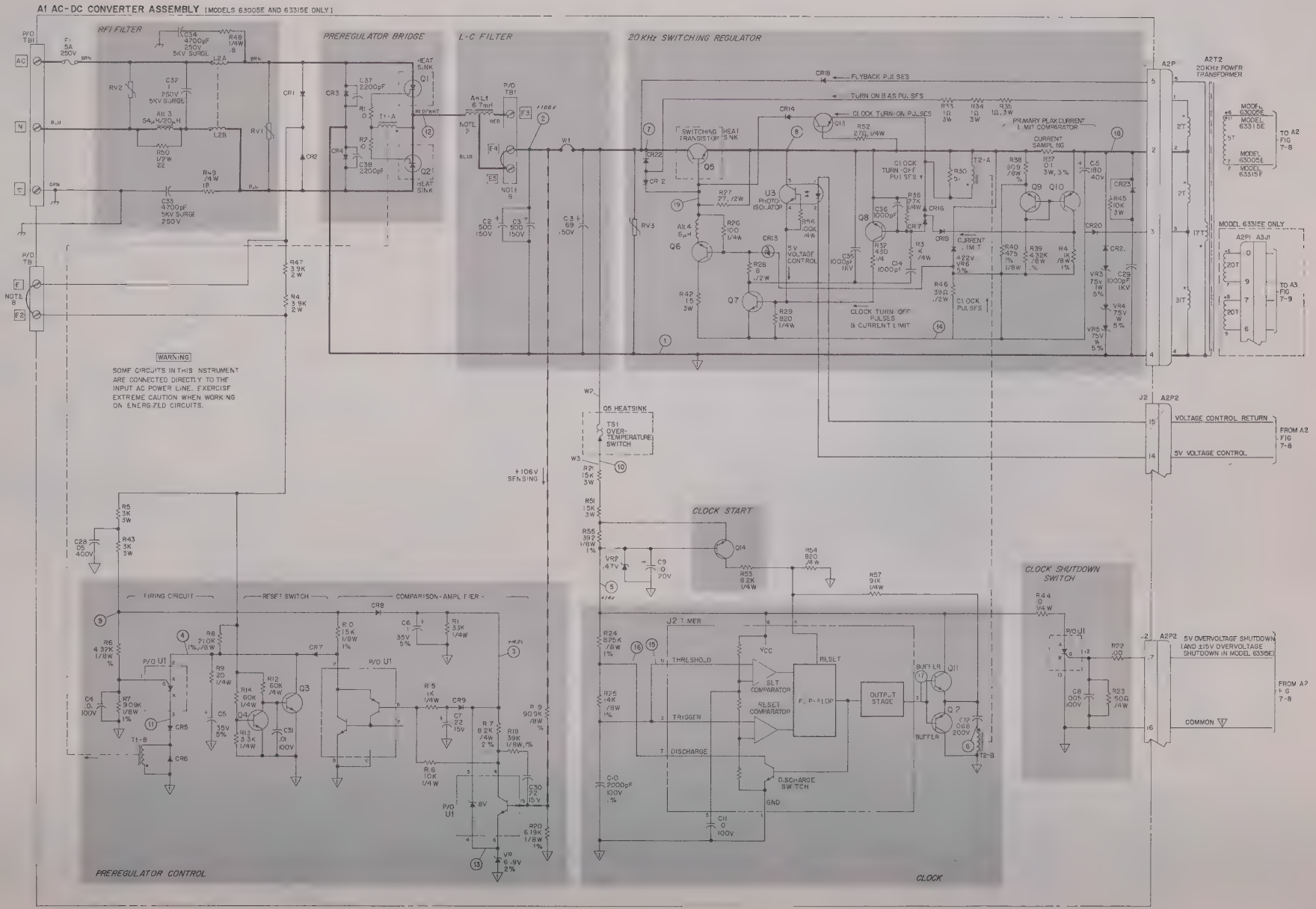


Figure 7-6. A1 AC—DC Converter Assembly, Models 63005E and 63315E

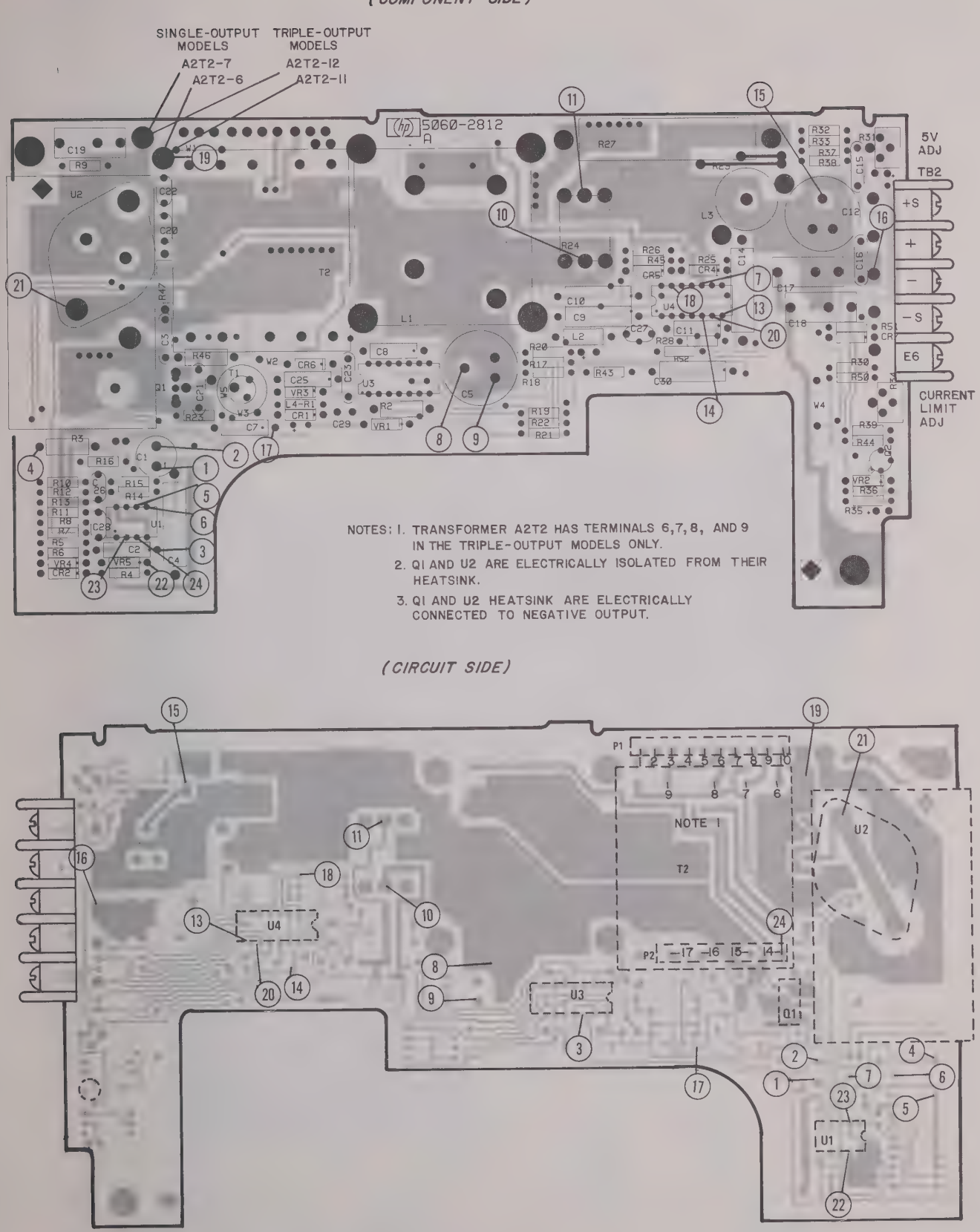


Figure 7-7. A2 5V Switching Regulator Assembly, Component Locations

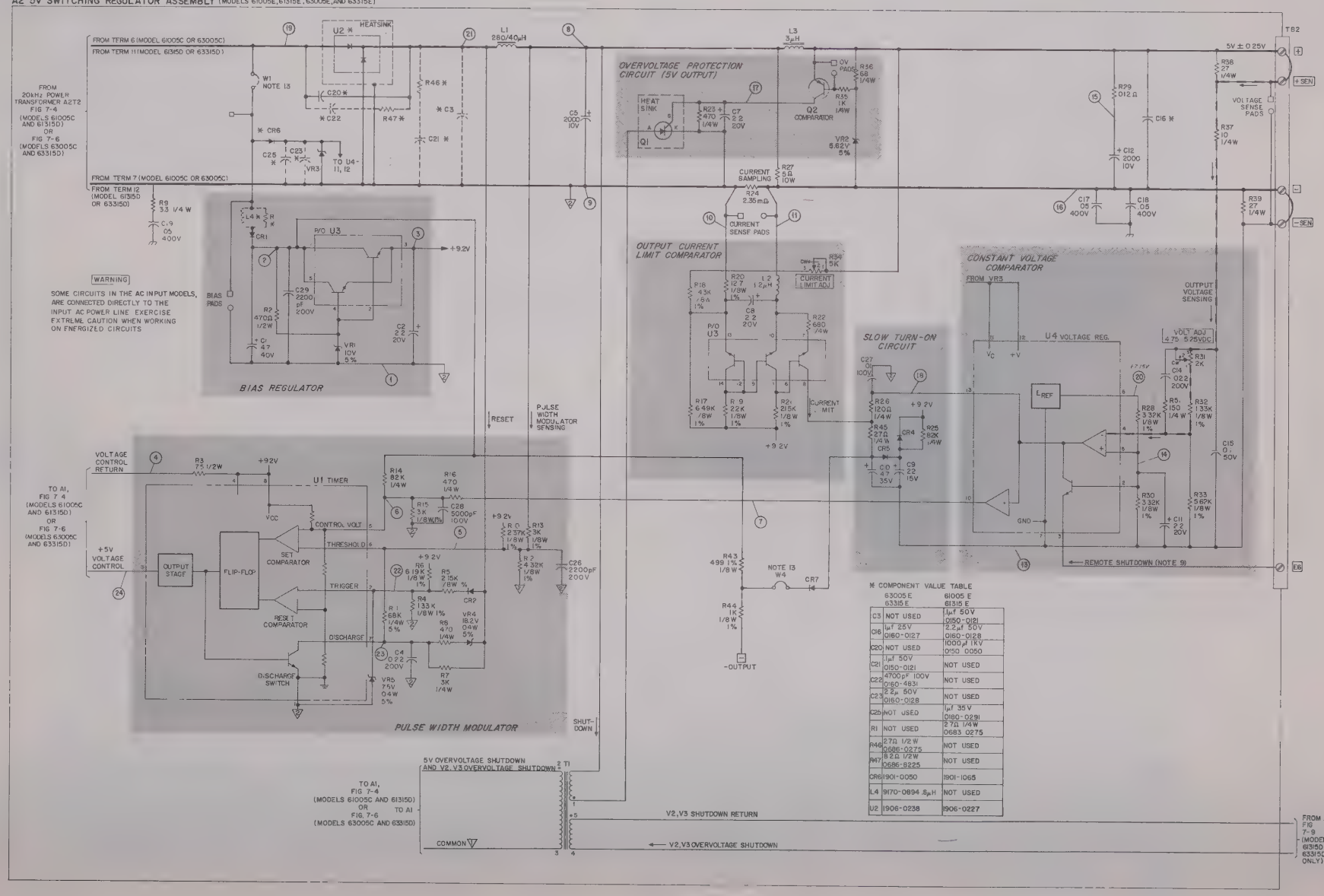


Figure 7-8. A2 5V Switching Regulator Assembly, Models 61005E, 61315E, 63005E, and 63315E

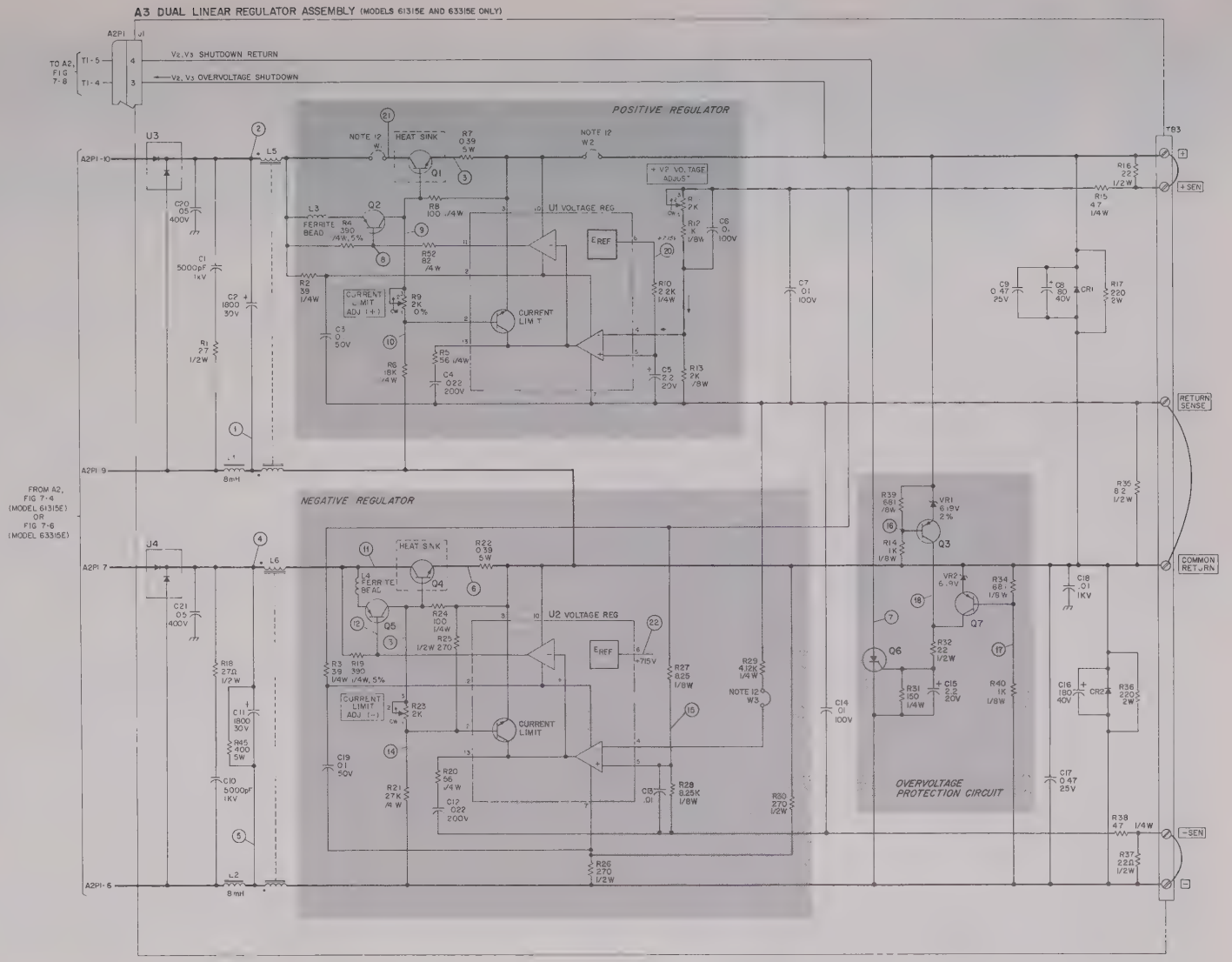
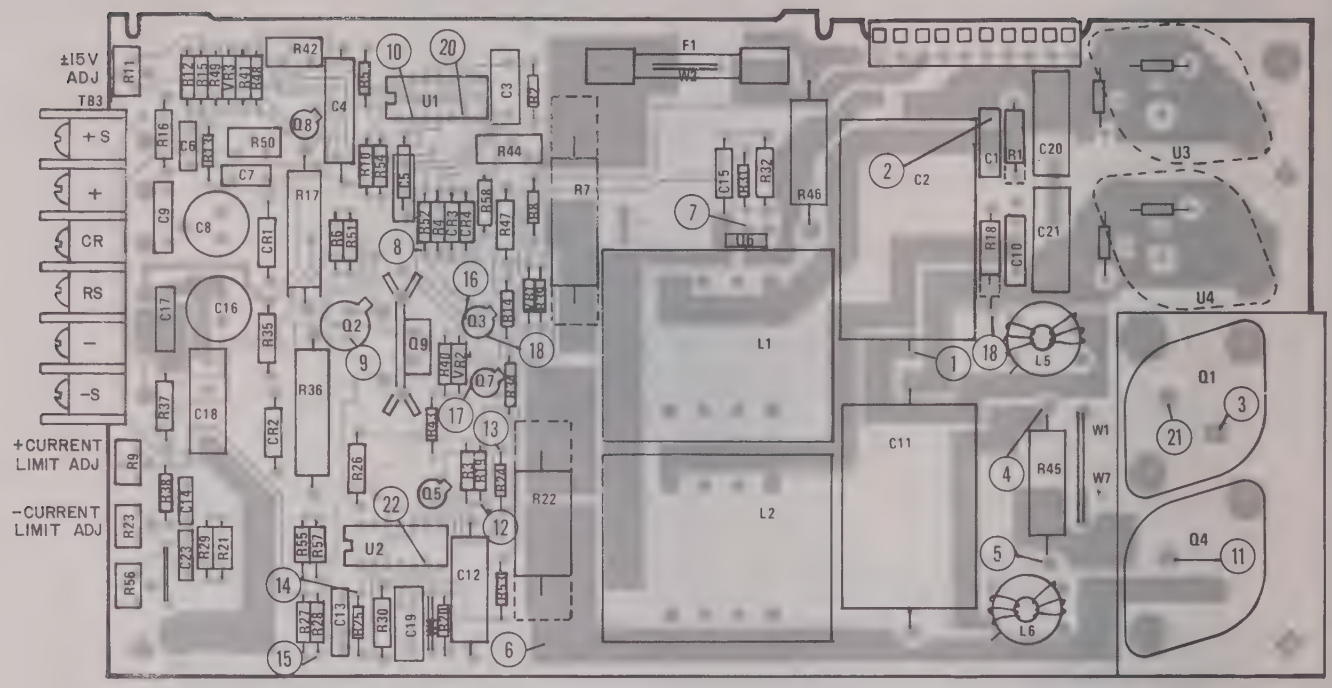


Figure 7-9. A3 Dual Linear Regulator Assembly, Models 61315E and 63315E

(COMPONENT SIDE)



NOTES: 1. THE FERRITE BEADS ON THE Q2 AND Q5 EMITTER LEADS ARE DESIGNATED L3 AND L4, RESPECTIVELY.
2. RESISTORS R41 THROUGH R44 ARE NOT USED IN A STANDARD INSTRUMENT.
3. Q1 AND Q4 ARE ELECTRICALLY ISOLATED FROM THEIR HEATSINK.

Figure 7-10. A3 Dual Linear Regulator Assembly, Component Locations

SALES OFFICES

Arranged alphabetically by country

ANGOLA
Telectra
Empresa Técnica de Equipamentos Eléctricos, S.A.R.L.
R. Barbosa Rodrigues, 41-1°DT.°
Caixa Postal, 6487
Luanda
Tel: 35515/6

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6140 **Buenos Aires**
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Telex: 122443 AR CIGY

Biotron S.A.C.I.y M.
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34-9356/0460/4551
Telex: (33) 17595 BIO AR

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Telex: 62650

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Telex: 21561

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Teachers Union Building
495-499 Boundary Street
Spring Hill, 4000
Tel: 2291544

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Telex: 82536

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Blackburn, 3130
Tel: 89-6351
Telex: 31024 MELB

WESTERN AUSTRALIA
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141 Stirling Highway
Nedlands, 6009
Tel: 3865455
Telex: 93859

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Wehlstrasse 29
P.O. Box 7
A-1205 **Vienna**
Tel: 35-16-21-0
Telex: 13582/135066

Hewlett-Packard Ges.m.b.H.
Wehlstrasse, 29
A-1205 **Wien**
Tel: 35-16-21
Telex: 135066

BAHRAIN
Medical Only
Wael Pharmacy
P.O. Box 648
Bahrain
Tel: 54886, 56123
Telex: 8550 WAEL GJ

Al Hamidiya Trading and Contracting
P.O. Box 20074
Manama
Tel: 259978, 259958
Telex: 8895 KALDIA GJ

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Dilkusha Commercial Area
Motijheil, Dacca 2
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Telex: 734

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06400 **Barueri** SP
Tel: 429-3222

Hewlett-Packard do Brasil I.e.C. Ltda.
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Ottawa K2H 8K7
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